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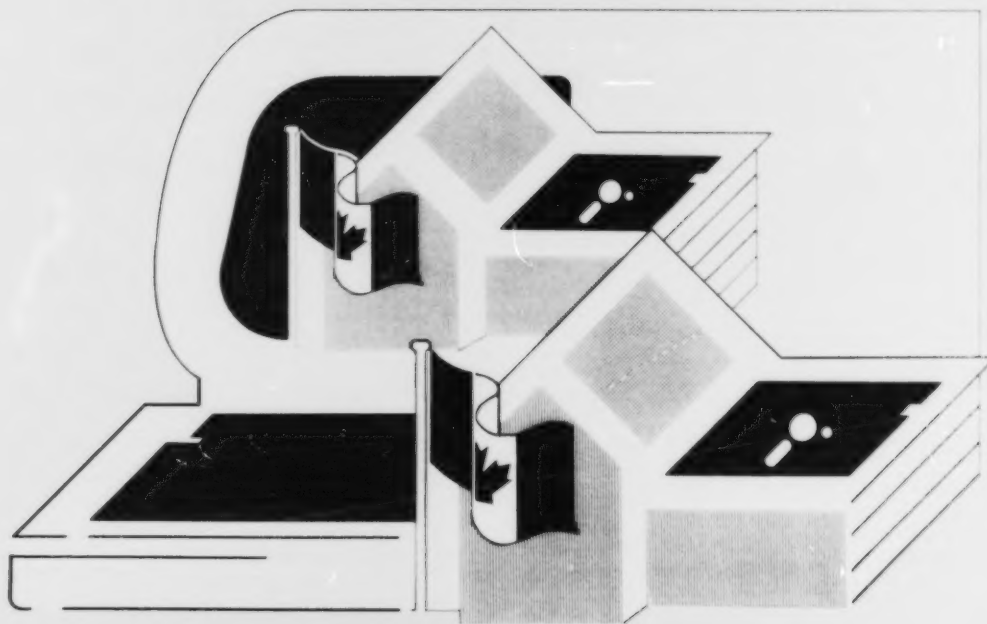
Ontario

Chris Ward, Minister
Bernard J. Shapiro, Deputy Minister

Computers in Education Centre

July, 1988

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Strategies for Implementing Microcomputers in Schools: The Ontario Case

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ABSTRACT

Getting microcomputers well implemented in schools during the next decade is a challenging, high-stakes task, and one which is at the top of the educational agenda in many countries. It is a significant change, and one which will have strong impact on student learning, on the work of teachers and administrators, and on family life. It is important that it be done well.

The Ministry of Education in Ontario has committed itself to full-scale, high-quality implementation of microcomputers in all Ontario schools by 1996. That is an ambitious undertaking, which will place heavy demands on all those involved. A clear, knowledge-based plan is needed, one that focuses on the "up-close" realities of using microcomputers in everyday classrooms.

Over the past decade, considerable knowledge has accumulated from research and practice on how to implement educational change. This report synthesizes that knowledge, applies it to the situation in Ontario, and creates an implementation policy and a recommended set of strategies that appear most likely to succeed. The strategies are designed to help the Ministry of Education, local school systems, and other agencies in implementing ministry policy and approved hardware and software effectively.

Data sources include interviews with key ministry, university and industry personnel, policy documents and reports, and several studies of the adoption and implementation of microcomputers in Ontario schools. Ten factors drawn from research on implementation provide the conceptual framework for analyzing and contrasting the government's broad picture of implementation on the one hand, with local implementation experience "up close" on the other hand. The ten factors are: clarity/complexity, consensus, quality/practicality, central office direction, process for implementation, professional development and assistance, monitoring and problem solving, principal's leadership, community support and environmental stability.

A general conclusion is that learning to use microcomputers and curriculum software in the classroom in ways consistent with provincial goals represents a difficult change in practice for most teachers. In addition to the availability of

easy-to-use technologies, curriculum relevant software, and introductory training, effective utilization will depend on ongoing assistance, clarification and innovation adaptation during the implementation. High uncertainty about the impact of the new technologies on learning outcomes and about the most effective methods of classroom use poses a major challenge for implementation on the part of teachers and administrators.

Focussing on the analysis of local experiences with microcomputer implementation, the following design requirements for a comprehensive implementation support strategy were developed: local responsiveness, initial acceptance of an uncertain innovation, provision for increasing clarity, learning maximization, high credibility, overload reduction, sustained responsive assistance, expansion of assistance capabilities, support for user interaction, clarity about principal's role, attention to time reallocating, early success, use of existing human resources, accommodation of old and new uses of microcomputers, non-reliance on software perfection, accommodation of range of user types, continued updated training for new software/hardware innovations, parent involvement, coordination among multiple agencies and visible progress and impact.

Based on these design requirements an adaptive approach to implementation is proposed. The overall approach consists of six strategic streams and associated activities: (1) competence development of teachers and administrators, (2) local consultant development, (3) stimulation/facilitation of naturalistic efforts at the board/building level, (4) diffusing and supporting effective practice, (5) user networking within and across schools and boards, (6) building the organizational capacity of boards and schools to manage change and of supporting agencies to help. Successful implementation of the ministry's priorities for microcomputer use in education will require an increase and reallocation of available resources to stimulate more support for implementation activities at the board and school levels.

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INTRODUCTION

"Knowing a little about computers is a dangerous thing. The more I learn, the more I realize how little I know. I am beginning to find this very intimidating" (Teacher, 4th month of use) Carmichael et al., 1985.

Implementing microcomputers in schools contains all that is fascinating in educational change: intuitive attraction and great uncertainty; excitement and hardship; enthusiasm and exhaustion; visibility and high public interest combined with unknown results. Ontario's expectations and approach to implementing new educational technologies (NET) in schools ups the stakes involved. (1) Sponsoring the development of its own microcomputer, funding the development of software geared to official curriculum goals and policy, focussing on the integration of computers into the total learning experiences of students - Ontario's approach is comprehensive. The technical accomplishments are considerable, but the knowledge and skill demands on teachers are huge. NET in Ontario is an ambitious innovation. The task is sizeable and multifaceted. While there is strong front-end financial support in launching NET, there is at this point a great need to build a knowledge-based strategy focussing on the "up-close" realities of using microcomputers in everyday classrooms.

This report represents an implementation analysis of the Ministry of Education's approach to the introduction and utilization of the new educational technologies in elementary and secondary education. It identifies key implementation factors especially at the local and classroom level, and recommends strategies for addressing those factors. The emphasis is on knowledge and competency oriented strategies that will generate and support high quality use in schools.

1 We use the terms microcomputers and NET interchangeably in this report.

The report has five chapters. Chapter 1 provides an overview of the nature of "the innovation" and a summary of ministry initiatives to date. Chapter 2 introduces some images of utilization in order to provide some concrete ideas of the direction of the change as it might ideally evolve in Ontario classrooms. In Chapter 3 we have identified ten major factors which will influence the degree of effective NET implementation in schools. Chapter 3 focuses on the following three subcomponents:

- explanations of key factors affecting implementation of educational innovations
- analysis of ministry perspective on NET with respect to each factor at the school board/school-levels
- analysis of field data on the situation of each factor at the school board/school-levels

Our purpose in Chapter 3 is to lay the groundwork for a "backward mapping" approach to analyzing needs for implementation support (Elmore 1978). Backward mapping takes the perspective and problems of innovation users in the schools as the primary basis for implementation planning, rather than the perspective of policy-makers external to the implementation settings.

Building on the previous chapter, Chapter 4 identifies a set of design requirements for a comprehensive NET implementation support strategy. Stated another way, Chapter 4 addresses the question: What are the main specific criteria that an effective implementation strategy should meet relative to NET in Ontario schools? In Chapter 5, we construct six components of an overall implementation support strategy, and assess their potential effectiveness in terms of the design requirements. The purpose of this chapter is to recommend specific strategies to strengthen the effective implementation of microcomputers in Ontario schools.

In summary, the overall logic of the report is to analyze the circumstances of microcomputer implementation within a framework of factors known to affect planned change, to identify critical implementation issues from that analysis, and to construct an implementation support strategy addressing those concerns.

Our understanding of the circumstances of NET implementation in the province is based on interviews with a select sample of ministry officials, University researchers and industry representatives closely involved with microcomputers in education, and on policy documents, reports and research studies made available to us mainly through ministry sources. The interview sample is described in Appendix 1. The interview guide and list of documents consulted are included as Appendices 2 and 3.

Our task was not to develop a precise blueprint for implementing NET in Ontario schools. We did not focus on specific problems; for example, the important question of the role of girls and women in using NET was not examined. Rather, our charge was to apply an up-to-date, rigorous implementation perspective to the challenge of making the use of microcomputers more effective. To this end we generate an explicit conceptual analysis and corresponding strategic plans. We did strive for clarity and practicality.

This report was originally commissioned as an advisory paper for the Ontario Ministry of Education in planning strategies to assist school boards and schools with implementation of its goals for microcomputers in education. Upon completing the report, it seemed to us, and reviewers who read it, that the analysis and strategies are of more general interest and applicability to those at school, district and policy levels in Canada and abroad, who are engaged in planning and implementing the use of microcomputers in elementary and secondary schools. Ministry officials and other sources familiar with the field of microcomputer use in education encouraged us to publish the document to facilitate its dissemination to a wider audience

CHAPTER 1 OVERVIEW

Implementation Focus and Scope

It is necessary to provide a brief summary of NET in Ontario so that we may understand it in its' own right, and so that we can place Ontario's initiatives in the context of NET more generally. Table 1 differentiates four key aspects of the general and specific focus of implementation: the technologies, the products, the user groups and expected uses. The analysis and recommendations presented in this report are directed mainly towards the specific implementation goals highlighted in Table 1.

Table 1 Implementation Focus of NET

	<u>General</u>	<u>Ontario Specific</u>
The technologies	All types of new educational technologies	Microcomputers and curriculum software
Products	Any microcomputers and educational software	Grant Eligible Microcomputers (GEMS) and software distributed by the Ontario Educational Software Service (OESS)
User groups	All teachers	Teachers using or planning to use GEMS and OESS materials
Expected uses	Any use in educational process	Use to support creative learning and provincial curriculum goals

The current focus of implementation is to assist teachers in learning to use microcomputers and educational software with students in the classroom. Other new educational technologies, such as messaging and conferencing systems, data bank networks, and videodiscs may have an impact on education, but their uses are largely unexplored at present. The kinds of issues raised and strategies considered in this report will likely apply to the eventual implementation of these other new educational technologies as well. However,

these issues and strategies are only addressed in this report insofar as they can be used to support classroom implementation of microcomputers and curriculum software.

School boards and schools in Ontario have been involved in microcomputers in a big way since about 1980. Ministry reports indicate a growth in the number of first generation 8-bit microcomputers in the schools from about 5,900 in 1982 to 45,250 in 1986. The kinds of hardware acquired - PETS, Commodore 64s, Apples IIs - vary between and within settings, and each branch of microcomputer requires its own software. Educational software for use on these systems is mostly commercially produced outside Canada, not highly regarded for its educational value, and not keyed to the Ontario curriculum.

The ministry's involvement dates from a 1981 decision to subsidize the development through private industry within Canada of a more powerful microcomputer (16 and 32 bit) specifically designed for educational use, and of compatible software appropriate to the Ontario goals of education and curriculum guidelines. The first machines meeting the ministry's functional specifications were piloted in select schools across the province during the 1983/84 school year. Encouraged by the availability of generous subsidies from the ministry, reasonably large numbers of these machines (ICONS) were acquired by school boards for the following and succeeding years. In February 1986, the ministry announced that a second microcomputer system developed by IBM would also be eligible for grant subsidies. As of September 1986, there were 14,170 Grant Eligible Microcomputer Systems (GEMS) in Ontario schools.

While the ministry does not prohibit school boards from buying less powerful and less costly microcomputers, provincial subsidies are only allocated to support the purchase of GEMS. Additional provincial funds to support the development of curriculum software and software utilities are directed almost entirely to the production and dissemination of software for use on GEMS. Ministry contracts to support software development for use on GEMS were first tendered in 1984. As of September 1986, 80 of these software programs had been developed, approved and distributed to school boards across the province. Distribution is accomplished under ministry contract by the Ontario

Educational Software Service (OESS), which is operated by the provincial educational television authority, TVOntario.

The ministry's goals are to provide sufficient numbers of microcomputers to allow daily access to every student. Early estimates called for one microcomputer per 10 students, or three to four per classroom, and about 830 software products covering all areas and levels of the provincial curriculum. The educational quality of the ministry endorsed and supported hardware and software is expected to push the competing products out of the schools. Despite the continued dominance of other microcomputers and other software in the school system, the thrust of ministry support for implementation will follow the direction of its support for hardware and software development, and focus mainly on the implementation of GEMS and OESS materials. Thus, our analysis and recommendations are directed towards the utilization of these kinds of equipment and materials, rather than to the general use of microcomputers in education.

In the long range, the implementation target population includes all current and future elementary and secondary school teachers in the province. Presently, these number about 92,000 teachers in over 180 school boards. In the short range, the target group is not nearly so large. The immediate focus for implementation assistance consists of teachers with access to GEMS who are already using them or plan to use them, either by choice or by mandate. Teachers who do not yet have access to GEMS in their schools, or who have access but remain undecided about their use, are more accurately regarded as future potential users, if and when the decision to become a GEMS user is made by or for them.

Findings from a 1986 teacher survey by TVOntario give a rough idea of the current scope of microcomputer and GEMS use across the province (Kwong 1986). Seventy-four per cent of the elementary teachers ($N = 709$) and 44 per cent of the secondary teachers ($N = 275$) responding classified themselves as microcomputer users. Only 11 per cent of the elementary teachers and 17 per cent of the secondary teachers, however, said they were users of GEMS (ICONS). The figures have to be interpreted with caution, however, since many of the non-respondents (48 per cent of all elementary teachers sampled,

N = 1358; 40 per cent of all secondary teachers sampled N = 457) were probably non-users. Adjusting the figures on that basis, a conservative estimate of the current microcomputer user population would be 38 per cent of elementary teachers and 26 per cent of secondary teachers. The figures for GEMS users would be on the order of 6 per cent for elementary and 10 per cent for secondary teachers. Of course, these numbers are increasing rapidly as more GEMS are acquired by boards and schools and as more teachers decide to give them a try. The simple notion of GEMS user, however, is not really a satisfactory measure of implementation, since it provides no sense of whether the technology is being put to use in ways consistent with the ministry's aim.

Provincial policy states that microcomputers should be available to all students. The ultimate goal is for every student to have access to 30 minutes of computer time daily. The issue, however, is not simply a matter of access to computers and software, but of the kind of learning experience students get when using them. In a 1982 policy/program memorandum (No. 42), the ministry announced its primary commitment to the use of the computer as a personal learning tool by individual students to support creative learning. More common uses of computers in education - e.g., accessing learning materials and information resources, content mastery, drill and practice, computer literacy - are acknowledge, but regarded as secondary goals and byproducts of the creative use of computers (writing, designing, problem solving, etc. For image of the latter see Chapter 2). The functional specifications for approved microcomputer systems and contract requirements for software development are geared towards ensuring that hardware and software appropriate to the creative learning goal are available.

Curriculum guidelines for optional courses in Computer Studies, Computer Science, Computer Technology and Data Processing were revised, consolidated and distributed in 1983. The implementation focus considered here, however, is not the implementation of these specialized courses about computers and computer applications. It is the use of microcomputers and software by teachers and students to support learning in all other subject areas, where the computer is not a topic of instruction per se, but rather a learning tool.

Summary

We can characterize the focus and scope of ministry support for NET implementation as follows. The thrust of implementation assistance will be directed towards the use of microcomputer systems and education software meeting ministry specifications (i.e., GEMS and OESS materials). Teachers already using or planning to use GEMS make up the initial target group for implementation support. While only a small percentage of teachers fit this designation at present, the numbers will multiply quickly over the next five to ten years. The majority of teachers are currently non-users of GEMS and approved software, but many have experience with other products. These teachers represent the primary target for dissemination to encourage adoption and implementation of GEMS and OESS materials. Implementation support activities will emphasize the creative use of microcomputers to support individual student learning consistent with provincial curriculum goals by all students. Use of microcomputers and software will be integrated into the teaching/learning process of all areas and levels of the curriculum. Ultimately, all teachers, classrooms and students should be involved.

A Chronological Summary of Ministry Initiatives

It is not our purpose here to describe the history of the ministry's involvement in supporting the introduction and implementation of microcomputers in education. In order to place the ensuing analysis and recommendations into historical context, however, a chronology of some key ministry initiatives should be noted:

- 1979 Formation of a strategic planning process which led to identification of the need to support new educational technologies in the schools.
- 1981 Ministry decision to support development of an educational microcomputer.

Ministry supports formation of Canadian company to develop the microcomputer.

1982 Contract research and provincial studies of current microcomputer use in Ontario schools undertaken.

Policy statement on creative use goal issued.

First RFP (Request for Proposal) for computer software development (8-bit Computers).

1983 Functional requirements (Stage I) for educational microcomputers published.

Policy statements re functional requirements, assistance for hardware purchases, educational software and planning issued.

New Computer Studies Guideline for Intermediate and Secondary Division issued.

Recognition of ICON/LEXICON system as a Grant Eligible Microcomputer system (GEMS).

ICON field trials get underway.

1984 Formation of Education Technology Development Division at Ministry

Formation of Ontario Educational Software Service (OESS) and distribution of 55 pieces of new software (Exemplary Lessonware Project).

Ongoing RFPs for software development for use on GEMS, including conversion of first OESS materials.

Development/distribution of Ambience (user-interface).

Recognized Extraordinary Expenditure (REE) grants made available to school boards for purchase of GEMS.

1985 Software development for GEMS and distribution through OESS continues.

REE grants for purchase of GEMS continues.

Policy statements summarizing NET initiatives issued.

1986 Announcement of approval of IBM product as a GEMS.

Completion of draft Stage II hardware specifications.

Continuation of hardware grants, software development and distribution.

1987 Policy statement summarizing ministry expectations regarding use of the technology in elementary and secondary programs.

Advisory bulletin with information on implementation resources and strategies, desired hardware and software characteristics.

Initiation of Lighthouse Implementation Project to demonstrate and document effective uses and implementation strategies in connection with computers in education.

As of 1987 then, major developments have been completed and are underway in the production of specified hardware and software geared to Ontario Curriculum Policy Guidelines across subjects and grade levels. Implementation, defined as widespread and quality use of Ontario-related NET is at the very early stages. Despite the strong start the challenge of implementation as outlined in the rest of the report is enormous.

CHAPTER 2 IMAGES OF UTILIZATION

In this chapter, we draw on ministry policy documents and our interviews with ministry personnel to construct a picture of how the new educational technologies might be used in schools when fully implemented. The goal is to obtain some concrete ideas and images of the nature of the change phenomenon with which we are dealing. Of course, the images of ideal use will evolve and become more fully specified in the next few years as more and better software is developed and as research and practice is refined and tested. Nonetheless, it is useful to start somewhere to obtain some clear ideas of the direction of the changes entailed.

IMAGES OF UTILIZATION

Ministry policy statements about the use of microcomputers in education focus mainly on the development and distribution of government approved hardware and software. As illustrated in quotes from key policy/program memoranda, statements about educational uses of the technologies clarify general expectations, but do not provide concrete images of teacher and student behaviors. For example:

Policy/Program Memorandum No. 47

Classrooms will have increasing numbers of "stand-alone microcomputers." Students will use these machines to do a variety of activities - analysis and reasoning exercises; simulation in subjects such as science, business studies, history, geography; word processing in English, French, business studies, and other subjects; graphics in technical studies, art and most other subjects; music training; record keeping; etc.

There will be two fundamentally different ways to use computers in the process of teaching and learning. The more significant way will be the creative use of the computer by individuals: writing, composing, designing, analyzing, and other extensions of original thought.

All students must be given opportunities to use computers in this way.

Policy/Program Memorandum No. 67

Ontario's curriculum policy stresses the autonomy of the individual learner. The computer should, therefore, be an aid to the individual learning tasks the student encounters and be readily available in every classroom whenever the need arises. The ministry believes, therefore, that the optimal use of the microcomputers in schools will be in small classroom clusters of microcomputers connected by a local network to a central nodal point at which there will be concentrations of electro mechanical devices such as printers and disc drives....The network should be expandable to 30 or more microcomputers in different classrooms or in a single "computer laboratory" for instruction in formal computer science.

Policy/Program Memorandum No. 82

The new user interface (Ambience)...will make OESS materials readily accessible even to very young students....The user interface and the OESS materials illustrate a wide range of possible curricular uses of computers. All children should be given opportunities to explore the potential demonstrated by these new materials. It is particularly desirable that the creative possibilities of the "WRITE" and "DRAW" functions be made available to Junior Division students.

Policy/Program Memorandum No. 91

All students in Ontario schools shall have the opportunity, to the full extent of their abilities, to become knowledgeable and creative in their use of computers as personal tools. Educators developing curriculum for children in the Primary and Junior Divisions shall therefore include computer applications, where appropriate, in the areas of study defined in The Formative Years. Educators developing courses of study for all subjects offered in the Intermediate and Senior Divisions shall also incorporate computer applications, where appropriate.

Ontario's curriculum policy reflects the need for flexibility and autonomy in learning. Computers can be used to support this policy; teachers are expected

to keep its implications in mind when choosing and designing computer activities for their students. Students should be given opportunities to use computers in a variety of activities, such as drawing, writing, composing, exploring, calculating, analyzing, role-playing, and accessing information resources. This can be accomplished through the use of word processors, simulation programs, graphics editors, should editors, spreadsheet, database managers, and telecommunications media. Students should explore the ways in which network configurations can provide a medium of communication and collaboration with peers and teachers both within and outside the school. Students should come to see the computer as a self-help tool of everyday life.

To get a better picture of desired utilization, we asked ministry personnel to describe how microcomputers and software might be used to best advantage in schools. These unofficial descriptions help clarify some of the anticipated educational uses of the technologies, though they do not constitute ministry policy. Indeed, ministry officials stress that the field is still too young to claim any definitive pictures of best utilization. The following vignettes illustrate major themes and variations in comments about imagined implementation, and are paraphrased from our interviews.

Microcomputer activity centres

Example A: I think there might be a half dozen workstations across the back of the classroom by the library shelf. The kids would be working along at their desks and moving back to software for a few minutes at a time. It becomes a classroom resource much like dictionaries and encyclopedias to which students periodically have access.

Example B: We perceive three to four network microcomputers in every class. It would become another activity centre, with bridges to the outside world and access to an entire library of software, such as word processing and any of the tools a student might use for a specific content area or more generally. Each student would be provided about 30 minutes per day with these microcomputers....Like resource materials in the library, it would be available for stimulation, practice and so on...

Classroom organization and grouping

- Example C: The classroom structure tends to alter considerably. It's no longer one teacher to 35 students. Rather it's one to six or even one to one. For example, I recently visited a classroom where the teacher had one-third of the students working on software, one-third working on a written assignment, and one-third discussing what they had been doing on the software. The teacher told me that it was the first time he had ever been able to teach kids how to discuss.
- Example D: Classrooms are being set up sort of like a cocktail lounge with kids clustered around a few machines. It will smash the row structure of the classroom, except in computer labs.

Teachers' instructional role

- Example F: A shift away from teacher-directed, content-focused instruction. I see the teacher shifting to being a facilitator and co-learner. Teachers and kids can explore things together.
- Example G: They must become comfortable as the manager of the learning instead of the controller....I guess we view the teacher becoming more the motivators and organizers of the learning environment and less of the content experts.
- Example H: My vision is that much of direct instruction, drill and practice would be automated.....The teacher's role would be individual counselling and a guide to resources.
- Example I: My current impression is that teachers spend a lot of time dealing with the class as a body. There will be a transition to a more individualized consultative process. I think the biggest difference teachers will see in the long run is that they will get involved in identifying kids' problems, identifying and exploiting their individual capabilities.

Learning content

Example J: It would be used to support every area of the curriculum.

Example K: Of course it is used in different ways in different subjects. Social studies simulations for deeper understanding of historical situations. Language classroom word processing software including dictionaries, writing aids and references. For science maybe a computer to support general learning, reference and simulations. And in science labs you'll have micros linked up to machines to record, collect data, etcetera. I also see them being used for remedial needs of students. So there is no one way.

Example L: Content delivery, drill....That kind of routine could be relegated to machines....Group things would be directed toward collective consideration of what the class has been learning. The teacher could work also on social skills in discussion.

Example M: I think in the ideal setting more time would be devoted to arts, physical education, and aesthetic education, since the computer frees up time because kids can master content more quickly.

Independent learning

Example N: The learning and mistakes are private. A kid can find his error, correct it, and move ahead on his own.

Example O: One of the things that can be done is to unload the teacher from a lot of stuff that doesn't have to be dealt with individually. The computer allows learner self-pacing.

Use of Ambience

Example P: On Ambience the student has a "personal space" which is like a notebook. There is a "task space" for teacher's assignments. There is a "display space" which is like a

bulletin board. And the student has access to different catalogues so that he can use programs such as Write, Draw, and Logo....and have access to materials in the OESS, public domain materials, and school-based materials in the central file.

Lesson planning and record keeping

- Example Q: There is a section in each software program that deals with pedagogy and use. There are instructions for teachers and ideas for integration with the curriculum, use and evaluation. We need to encourage teachers to go into that section.
- Example R: The management role will be important in the regular classroom for keeping track of what each student is doing...their progress.
- Example S: On the administrative side teachers can provide better service. For example, in organizing timetable and in mark reporting.

Student to student interaction

- Example T: It is a very convivial technology. It encourages kids to talk to each other.
- Example U: It forces kids to work cooperatively....They will force communication, albeit via computers.

Networking between users and to data bases

- Example V: The whole networking area....Our use of the word "networking" refers not only to teachers between schools, but also to kids networking with classrooms and schools. Where what you do on a program affects what I do on that program in a situation where kids are at different terminals.

Example W: Networking....Linking together teachers and students from different schools. Utilizing the communications ability to support learning, such as comparing views and getting information from people in other places.

Example X: ..the ability for teachers to communicate with other teachers using different programs so that they could be sharing experiences and suggesting problem solving.

Example Y: Also there would be access to outside data bases for research....The librarian would help access them.

Utilization of associated technologies

Example Z: They would not just be using microcomputers and regular software. They might be using video discs....There would be other technologies involved, though the microcomputer is the glue that holds it together.

Supportive organizational arrangements

Example AA: Teachers have to have time to learn about a program and how to incorporate it into daily activities.

Example BB: We would like to have a site administrator. Someone in the school who is able to load software into the fileserver and to be able to dump stuff and archive it. The site administrator would help teachers set up programs and would be able to recognize when there are minor and major problems and who to call.

Example CC: There is a need for a small group of professional resource people at a local or regional basis to deal with technical problems.

Principal's role

Example DD: I don't see it as being very much different. But hopefully he would have a fair amount of technology available to

support his role, to manage such things as pupil records, attendance, produce reports, collate information and so on. That would leave the principal more time to perform his people person role. One task that will change is his view of how he will supervise and evaluate staff.

Example EE: They need to be familiar with use of the machines and supportive of the use of the machines....I think they'll have more time to be the principal teacher. This is a side effect of new software developed to handle and alleviate administrivia. That will free the principal to be the principal teacher and to be the principal interface between the community and the school. They will have more time to spend in the classroom.

The foregoing interview comments provide a composite view of some of the main potential uses of new educational technologies in schools from the perspective of ministry personnel. From this picture of utilization, the introduction of new educational technologies in education appears as a bundle of innovations, rather than as a single innovation. Some components of change such as the creation of activity centres, classroom reorganization, materials and content, teacher and student roles are closely interrelated. Others, such as lesson planning and record keeping, user networking and the use of peripheral technologies can be separated from the core changes in the learning and instruction process in the classroom. Still others highlight the multi-role and organizational implications of implementation - e.g., changes in the principal's role, creation and institutionalization of new support positions, and restructuring work-time allocation.

In our model of the change process, implementation refers to the phase during which teachers are actually attempting to alter their customary practices while using the innovation. In terms of that model, the illustrations above give an idealized picture of the outcome of implementation. They do not depict the process, real or imagined, through which teachers are expected to accomplish the change, a task to which we now turn.

CHAPTER 3 IMPLEMENTATION PROCESSES AND FACTORS

The question we address in this chapter is: given the nature and goals of NET, what do we know about implementation of innovations and how would this apply specifically to the situation at hand. The most useful place to start is to provide an overview of the implementation change process as we see it (Figure 1).

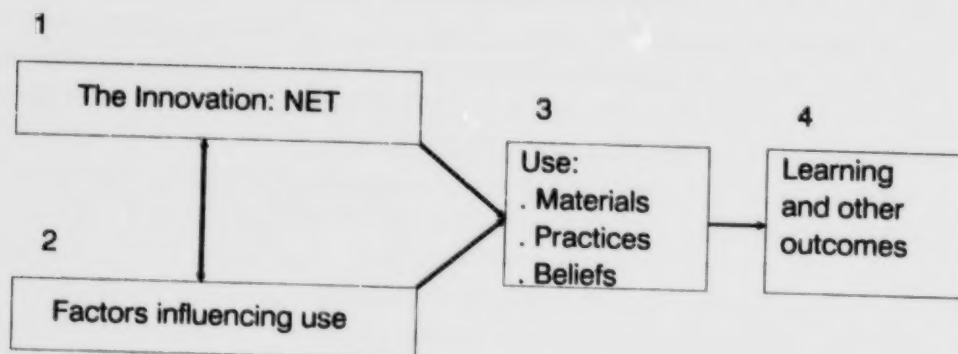


Fig. 1 An Overview of Implementation

We start with Box 3 and ask the direct question, "what types of things would have changed in the classroom if NET were to be implemented?" We have just presented a range of images of the types of changes that might occur. While it is an oversimplification, we could say that these images cover at least three aspects or dimensions of change for the teacher in the classroom:

1. the use of new hardware and software materials;
2. the use of new activities (including grouping) behaviours or practices;
3. changes in beliefs and understanding.

The use of new materials (hardware and software) is the most obvious because it is concrete and tangible. One can observe materials, and can readily answer

the question of whether microcomputers are actually being used in the classroom. The second and third dimensions are much more fundamental and problematic because they involve, respectively, changes in what teachers do (practices and underlying skills) and think (beliefs and understandings). Especially in the use of NET we maintain that the pedagogical use of software - the most effective teaching practices in relation to particular pieces of software - and the corresponding conceptual understanding vis a vis particular software are: (a) not well specified, developed, or known; (b) are complex; and (c) are at the heart of successful or unsuccessful implementation. We also suggest that the production of software per se, will not resolve this problem (although it is one important step in that direction). We shall return to this point time and again - the actual effective pedagogical use of software in the classroom - but at this stage, we are essentially highlighting the central implementation problem, namely, the process of implementation is, above all, one in which teachers learn or do not learn new practices and obtain new understandings about effective uses of NET. Without such learning, the surported learning outcome (Box 4) will not be achieved.

The next question is, "What factors (Box 2) influence the likelihood of effective use?" That is what will help or hinder teachers as they attempt to come to grips with mastering new practices and achieving deeper understanding of the specific uses of NET in their classrooms.

In the remainder of this section we focus on ten factors known to influence implementation use. In effect we are specifying the contents of Box 2. Drawing on the research literature, we start with a brief explanation of the nature and effects of each factor. We follow this with a description of the ministry's current perspective, actions or plans vis a vis the factor in question. (We label this the view Broad Picture). The ministry views are based on our interviews and document analysis. We then contrast the provincial level view with implementation data from the school and school board level (labelled Up Close). These implementation data come from the field studies examined (Appendix 3), and from reports of field contacts in the interview data.

We should emphasize that it was beyond our terms of reference to collect new implementation data. In a field as timely and dynamic as NET, there are

hundreds of activities ongoing in the field. Many Boards of Education have computer coordinators who are engaged in a variety of computer focused projects in schools. Faculties of education have developed Additional Qualifications courses in which hundreds of teachers are involved. The Educational Computing Organization of Ontario (ECOO), teacher federations and other organizations run seminars, conferences and workshops. In our view, the dynamism of the field is all the more reason to address, seriously and explicitly, the key factors in implementation.

The ten implementation factors listed in Table 2 are based on the accumulated research on innovation implementation in education, and have been found to be present in large numbers of situations of educational change (e.g., Clark et al. 1984; Crandall et al. 1983; Fullan 1982, 1986; Fullan, Anderson and Newton 1986; Huberman and Miles 1984; Joyce et al. 1984; Loucks-Horsley and Roody 1986; and Odden et al. 1986, to name only a few). The focus is on key factors at the school board and school levels, which should provide the framework and target for direction and assistance from the ministry. In Table 2 we do not include factors external to local conditions because they are the focus of Chapters 4 and 5 when we examine strategies.

We start with a discussion of the relevant characteristics of each factor as a foreground to our analysis of each factors as applied to NET in Ontario. Each of the ten factors is considered from two perspectives, namely the "broad picture" (ministry level) and "up close" (School level). Both perspectives are legitimate but often different from each other in terms of needs and experiences.

In considering these factors it is useful to keep three additional components of our implementation perspective in mind. First, implementation is a developmental process of change for teachers attempting to use an innovation, which can involve alterations in materials, instructional practices and beliefs about the teacher/learning process. Second, implementation is the second phase in a three-phase process of innovation - initiation (mobilization, adoption), implementation and institutionalization (continuation, incorporation). Third, the factors operate as a system of variables over time. They are mutually reinforcing, and the strategic importance and activities associated with any one factor can vary at different phases in the overall process.

In this report, we focus primarily on factors affecting the implementation phase, with the understanding that attention to factors affecting institutionalization is part of effective support for implementation. Recall also that in this section we are explaining the nature and role of the factors. We are not addressing the question of what to do about them, which is the goal of Sections IV and V.

Table 2 Factors Influencing Implementation

Characteristics of the Innovation

1. Clarity and complexity
2. Consensus/conflict about the change
3. Quality and practicality of the change

Local Conditions

4. Central office direction, commitment and support
5. Process for implementation and institutionalization
6. Professional development and assistance
7. Implementation monitoring and problem solving
8. Principal's leadership
9. Community support
10. Environmental stability

Before turning to the specific factors, we should state explicitly why the framework and ten factors deserve careful analysis, deep understanding and appreciation, and close attention at all stages of the planning and implementation process. First, the evidence is very strong, we would say overwhelming, that the ten factors and associated processes, directly affect the quality of use of large scale innovations. Second, the framework is deceptive. On the one hand, the ten factors make common sense and seem obvious. On the other hand, understanding and working with particular factors in particular situations requires great sophistication and consistent attention. To take two examples: (1) the quality of an innovation is obviously important, but producing high quality software is only a first step, which does not remove the problem of figuring out and implementing effective teaching practices in relation to the software, and (2) professional development and assistance is critical, but

designing and achieving an effective ongoing coordinated system of inservice assistance is enormously challenging.

We now take up the ten factors. In each case we have attempted to highlight the "Broad picture" and "Up close" perspectives by identifying the main points in box format.

A CHARACTERISTICS OF THE INNOVATION/NET

1. Clarity and Complexity

In order for implementation to succeed, implementors have to gain a clear understanding of what to do and change in order to put the innovation into practice. Policies, written guides, inservice programs, and participation in innovation development can help clarify the meaning of change for those involved. True understanding, however, only comes when teachers are given opportunities and time to work with the innovation in the classroom and to talk about what they are doing with others.

Educational innovations vary widely in their initial explicitness. When innovations have been thoroughly debugged and when replication of exemplary practices is the goal, or experimental programs are being tried out under controlled conditions, a high degree of a priori procedural specification is justified and useful. When the technical certainty of new practices is in doubt (as with NET) and considerable development or adaptation is needed, much more care must be given to documenting effective practices. In either case, clarity is something that has to be accomplished by teachers in the process of learning how to put the innovation into practice.

Some educational innovations are more complex to implement than others. For individual implementors, innovation complexity arises from the number of components of practice affected, the degree of difference from existing practices, materials and beliefs, and the difficulty of learning to make the necessary changes. While more complex innovations requiring major changes are harder to gain clarity about and more difficult to implement, they are also

more likely to yield non-trivial results than innovations which demand less personal effort and organizational support.

One of the dangers of complex innovations is that implementors may develop a sense of false clarity if they only incorporate the easy to learn features of the innovation into their practice. Or if the change is experienced to be complex and overwhelming without substantial progress, users often give up "down-size" or trivialize the change (see Huberman and Miles 1984). In either case, the expected impact of the innovation will likewise be reduced.

CLARITY.

Broad picture: Uncertainty about NET use is acknowledged, and approach through policy memos, standardizing easy-to-use hardware and software, and by identifying effective uses through research.

Up close: Much teacher difficulty in understanding; clarity takes many months to achieve and even then may be superficial. Students often are not clear either.

Clarity: Broad Picture

Notwithstanding their descriptions of ideal utilization, ministry officials emphasize that there is still great uncertainty about student outcomes and about effective organization and use of the technologies in schools, particularly in their use to support creative learning. They see a need to foster variation in use initially and to identify effective uses through research. The macro-level picture is less one of teachers coming to understand the use of proven practices during implementation, than of teacher understanding during early implementation resulting in increasingly precise and convergent knowledge about the characteristics of effective technologies and their use.

Ministry attention to the needs of school systems personnel for clarity about the implementation of GEMS and OESS materials has focused mainly on giving policy direction through policy/program memorandums and statements about computer applications in new or revised curriculum guidelines, and on controlling the characteristic of hardware and software. Two key objectives of the ministry's hardware and software development strategies are to standardize

the equipment and materials in the schools and to make the technologies as easy-to-use as possible for teachers and students. Software developers contracted by the ministry must specify in their program design such things as users, objectives, software type, roles, tracking strategies and suggestions for incorporating the software into the curriculum and classroom. Software operating instructions and supporting documentation (i.e., supplementary directions) are to be built into the programs for "stand alone" use. Attempts at large-scale implementation have been deliberately delayed until there is a large enough hardware/software base from which to work.

Clarity: Up Close

Findings from school-level studies of early users of GEMS, OESS materials or other creative software indicate that getting clear understanding of what to do and change is difficult for teachers, despite provincial pronouncements and the best efforts of software developers.

Field test reports on OESS materials highlight the difficulty teachers have understanding how programs work and could be used, and what role teachers should play.

The actual instructional role of the lessonware in some field-tests might have been different from the intended role because of a failure to distinguish between material intended for initial presentation and material for review or practice. (Pike 1985)

A principal difficulty with the SHAPEMATE program is that students and teachers alike do not understand how to operate the program. In almost all cases, they needed to be carefully shown how to use the program and what could be achieved with it. Also, they fail to appreciate its full capability. (Gillis 1985)

Many programs fail to explain the teacher's role. As a result, teachers frequently underestimate the amount of guidance certain programs require, particularly simulations. This is a common factor in many otherwise sound programs that fail to live up to expectations and draw teacher criticism. (Gillis 1986)

Such findings cast doubt on the notion that increased specificity in software documentation is likely to produce the degree of implementor clarity needed for effective utilization. We maintain and shall elaborate later that attention needs to be shifted to identifying and developing effective teaching practices in relation to each software program.

Carmichael et al.'s (1985) case studies of 13 teachers attempting to use Logo and the Bank Street Writer word processing program document the process of clarification teachers experience over a 12 to 24 period. The researchers describe considerable experimentation before the teachers settled into stable routines. They also discovered that clarity about the creative use of the programs depended on an understanding that went far beyond the operational procedures of program use.

It became obvious rather quickly that if learning was to take place in an interactive and creative manner, teachers needed a "sense" of direction which went beyond knowing Logo as a computer language.

Since the emphasis of this study was on the creative use of computers, teachers were compelled to re-examine the meaning of creativity and the appropriate teaching strategies that would allow creativity of expression. This often led to a reassessment of fundamental teaching philosophies and strategies.

Lee (1986a) assessed the effects of an intensive computer inservice program in terms of system-wide objectives stated in the training manual. Elementary teachers were trained to use ICONS and specific software (word processing, graphics, and problem solving programs converted for use on ICONS) with students in microcomputer labs. The labs rotated among schools in each of six families of schools, remaining for about ten weeks in each school. The initial inservice included 16 hours hands-on instruction with consultants, immediate application with students, teachers' manuals, and coaching and consultation with special computer resource teachers (see the Professional Development section for more complete description). Lee was involved initially as one of the computer resource teachers and later as a researcher. Her first study covered the school year of the inservice in five schools within one of the families, and was based on an analysis of program documents, a 14-item survey completed by

teachers at the end of the inservice, participant observation, and teacher interviews. Lee's data are interesting from an evaluation standpoint because she found that the survey responses given by teachers did not jibe with what she saw and heard going on in the classrooms. Her observation data and interview data from this and a follow-up study the next year (Lee 1986b), are cited numerous times in this report, because of the empirical insight they provide into the process of implementation. Lest the reader misinterpret our intent, we should emphasize that the initiatives and inservice program in this board were exemplary in many respects, that Lee's findings do not diminish the value of the inservice, and that her studies were only carried out in a small number of schools in relation to the 60 participating schools. Her findings, however, do bring into focus the complexities and pitfalls of implementation, as well as some of the successes in those boards which are leading the way in implementation initiatives.

Survey, observation, and interview data from Lee's analysis of the effects of the initial inservice in five schools provide insight into the short-falls of false clarity during implementation (Lee 1986).

A few teachers stated they were very comfortable using the computer. Lab observation showed they were. Unfortunately, they had stuck to using one program only: the easy-to-use DRAW program. They taught their students only limited functions that they themselves know well, and used this graphics program repeatedly without trying any other software during the entire inservice training and follow up period, even though all teachers were shown how to use both EDIT and LOGO programs. Consequently, these few teachers and their students reported, if somewhat misleadingly, that they were very familiar and confident with the use of computers.

In using the DRAW program, for instance, a majority of the teachers followed precisely the suggestions given in the manual by instructing all students to draw a flag on the computer without relating the activity to anything they did in the classroom. It is doubtful whether this could be regarded as a demonstration of true integration with the curriculum.... Most teachers were unclear as to what was meant by integrating computers into the curriculum. Many regarded any drawing using the computer as integration of Art in the curriculum,

and any typing of words using the computer keyboard as integration with Language Arts.

These examples suggest that even a combination of state-of-the-art software, explicit directions and intensive initial inservice may not be powerful enough to produce clear and full understanding of the innovation during the early period of change (this does not imply that clarity did not develop through continued use and assistance in the schools Lee studied).

A key finding of all the field reports reviewed is that successful implementation of creative learning activities depends in large measure on the individual student's understanding of how programs work and their potential uses. Students, particularly younger ones, often ignore directions written into the programs, and show limited capacity for independent exploration of the creative potential of open-ended programs. The importance of close supervision and guidance and stimulation from teachers is repeatedly cited as an unexpected (and welcome) finding.

COMPLEXITY.

Broad picture: The scale of the effort is enormous. And NET is seen as complex, requiring far more change in the teacher's role, classroom organization, methods, and content than most prior innovations. The range of software types and sheer number of different programs is also large.

Up close: Even with easy-to-use, well-supported NET, tried by highly motivated teachers, early use is often frustrating and difficult. And it gets more complex the more teachers learn about NET. Integration with regular classroom activities and the curriculum presents major problems. NET does in fact require much change in users, much time, and much learning support. Partial or superficial use is a natural teacher response. Students also have difficulty using software to its potential without close teacher guidance.

Complexity: Broad Picture

The first order of complexity for the ministry is simply dealing with the organizational magnitude of the installed base goals - i.e., placing three to four GEMS in the classrooms of 100,000 teachers and developing and distributing

about 830 pieces of software covering all grade levels and areas of the curriculum. These necessary mobilization-oriented concerns have tended to overshadow the complexity of using the technologies, once they are in place.

The ministry's basic approach to reducing the complexity of NET implementation for users is to force the evolution of common hardware and software characteristics, and to encourage the development of very easy-to-use equipment and programs. Thus, efforts are being made to reduce the potential complexity of implementation, but little attention up to this point has been directed provincially to the experienced complexity of the change process for users.

While not much supportive action has been taken as yet, officials interviewed do convey an awareness of several aspects of the complexity of NET implementation for users. The description of ideal utilization presented earlier demonstrates a sense that "full implementation" of the technologies would affect and alter many components of teaching practice (e.g., teacher and student roles and relationships, teaching and learning activities, classroom organization, content, pacing, evaluation and record keeping) and could involve fundamental changes in teacher beliefs about the nature of learning and the role of the teacher.

The ministry envisions the new technologies being used to support such long standing educational aims as the following: accommodation of a variety of student learning styles and needs, individualization of student programs, development of critical thinking skills and skills in the process of learning, developing skills in decision making and in collaborating with others, and fostering positive attitudes towards self and learning. From the broad perspective, thus, NET implementation does not imply a total reordering of teachers' pedagogical practices and beliefs, but rather an extension of existing policies, and associated pedagogy. Realistically, however, many aspects of these policies are not well worked out at the level of practice and there are probably many teachers whose beliefs and practices are only partially consistent with official policy. The complexity of the change for these teachers will be substantially greater than for those already into student centred, process focused learning, using a variety of activities, materials, instructional groupings and so

on. Although ministry expectations regarding use of the technologies are consistent with existing policy images of the learner and learning process, ministry officials believe the degree of change confronting teachers differs from that associated with routine curriculum changes.

We'd like to encourage recognition that teachers are starting from base zero. It's not like a new content guideline. They are not implementing a rehash of what they already know. We need to recognize the fact that it is a major growth for teachers.

They talk about potential major changes in classroom organization (physical arrangements, timetables, grouping) and teacher roles.

They also recognize something of the developmental and incremental nature of the change for most teachers - the fact that many have high personal concerns about using the technologies that have to be dealt with at the outset; the need to just get teachers comfortable with operating the hardware and software before expecting them to use them effectively in the classroom; that learning to use the technologies to their full potential will be a long-term process.

As suggested in the following quotes, ministry officials expect the difficulty of implementation to vary for different groups of teachers.

Elementary vs Secondary Teachers

I think maybe a different mode of teaching. Not the teacher at the blackboard expounding on the subject....Possibly less threatening in elementary schools where instruction is more integrated and there are often kids working in groups on different tasks. Elementary teachers are used to coping with that situation. Computers fit into that situation nicely.

Traditional vs Non-Traditional Users

Secondary teachers other than Computer Science and Business will find it more difficult to use. Subject teachers need new models. That is part of the challenge for implementation.

Experienced vs Inexperienced Teachers

From what we know, older more experienced teachers by and large are more effective in using computer technologies and in facing the kinds of questions kids ask than beginning teachers.

There is an implicit feeling that teachers already using microcomputers other than GEMs and commercial software will have less difficulty implementing GEMS and OESS materials than those who are totally non-users.

Another dimension of implementation complexity evident in interviewee comments and documents is the variety of software teachers are expected to master. Computer-based learning materials may employ different instructional strategies - educational game, educational tool, simulation, testing, tutorial or utilities such as word processing and design. They can vary in their emphasis on skills or knowledge acquisition, and in whether they are designed for presentation of new material or to reinforce skills/knowledge students have already acquired (Pike 1985).

There is also the sheer number of programs teachers will be expected to use. Assuming the accuracy of current software development projections, for example, P/J Division teachers would be confronted with items of "courseware" for each major element of the curriculum and additional 15 lessonware" items for each grade level (Ministry of Education Executive Committee Paper 1986). While there are common skills and pedagogical practices across software, to a certain extent, customized skill-in-use must be developed with each software program.

Complexity: Up Close

Data on teacher-level NET implementation highlights the complexity problem as experienced by teachers. Field data indicate that microcomputer implementation is often a difficult experience even for interested teachers using high quality software with good organizational supports.

The frustration and difficulty of beginning implementation is a common theme. Similarities are evident in examples of beginning implementation from Carmichael et al.'s (1985) study of the unsupported (i.e., no training or consultative assistance) use of Logo, and from Lee's (1986) studies of microcomputer use during and following an intensive inservice course on the use of ICONS and OESS materials.

Unsupported initial implementation (Carmichael et al. 1985)

(Classroom setting/teacher report) some pupils are overbearing. Constant interruptions. Teaching today was a bust. I felt like I lived in the centre of a three-ring circus. I solved this problem by giving a structured lesson.

(Computer lab/teacher report) ...the first trip to the computer room was overwhelming. It took 15 minutes to boot all the computers since there was only one language disk. I found that I could spend no time with any one group. I will not go there again until there are more disks and some help with booting the machines. I have found this experience of no benefit to the children and too overwhelming for me.

Supported initial implementation (Lee 1986a,b)

One Grade 8 teacher noted at the end of the 16 hour inservice course that she was still uncomfortable, worried and nervous about teaching the EDIT and LOGO programs to her students. She felt helpless and frustrated when computer problems arose and things went wrong which she did not know how to fix..(Lee 1986a)

Neil Perkins, at St. Rupert and Bertha (1), was a reluctant and a near non-user during the inservice training period last year. He claimed to have no computer background whatsoever, and did

1 Lee used pseudonyms to maintain the anonymity of the board, schools, and teachers in her study.

not understand why the computer acted strangely when he pressed the keys. He found the 16-hour inservice training very confusing and frustrating because it covered too many things in too short a time. He felt that he could not, and did not, absorb all that new learning at once. To him, this first computer experience was a total disaster and most unrewarding. He avoided the computer like the plague (Lee 1986b).

While we cannot say with certainty how typical these examples were for all teachers involved in NET use in these two situations, such findings recall those reported for other educational innovations involving substantial change in practice, in that beginning implementation is characterized by frustration and difficulty organizing and managing use of the innovation. They also echo the findings in Huberman and Miles; (1984) in depth case studies of educational innovations that user implementation of major changes is frustrating and difficult, no matter how much initial assistance is provided.

The picture is not all bleak. Despite the rocky start, the teachers cited in the examples went on to become competent users of the technology in the classroom. Most of the 13 teachers involved in Carmichael et al.'s Logo study managed to overcome the frustrations of beginning implementation by trial and error. Despite a lack of organized training and support, teachers in this study were highly committed volunteers using well-proven software. Even so, some found the initial experience too overwhelming, and without access to organizational assistance, they gave up. Lee cites cases of teachers overcoming initial difficulties, largely as a result of direct assistance from skilled colleagues in the school, ongoing contact with a board consultant and persistent personal effort (e.g., spending personal time practicing and studying). This suggests that ongoing user training and assistance in helping teachers cope with the early complexity of implementation is critical for NET (see Professional Development and Assistance).

Another theme in findings from the Logo study is that teachers underestimate the complexity of implementation. Citations from Carmichael et al's report highlight different dimensions and consequences of this unanticipated complexity (headings added).

Open-ended knowledge requirements

(Teacher quote, 4th month of use) Knowing a little about computer is a dangerous thing. The more I learn, the more I realize how little I know. I am beginning to find this very intimidating.

False expectations re difficulty of mastery

Even teachers who were very eager to participate did not realize the large and personal cost involved, in both time and mental energy, in dealing with this kind of innovation. Enthusiasm and dedication...became essential for overcoming the many difficulties...

Logo itself because it is so easy to produce "something" very quickly, tended to create unreasonable expectations about the time required to master the language.

All teachers experienced period of impatience. They felt they weren't developing their programming skills quickly enough, especially when they found their students moving forward rapidly.

Inability to stay ahead of students

...since teachers were still struggling to learn Logo, they were limited in the kind of guidance that they could offer their students. Students who had been in the study for two years, for example, explore little beyond what they had learned during the first year. Although teachers allowed students to take charge of their own learning and actively encouraged them to do so, a sense of unease developed even among those teachers who had the greatest computing expertise when some of their students surpassed them.

The study focused on the creative learning potential of computer-based learning materials. This finding of escalating as opposed to diminishing complexity of implementation over time is not typical of curriculum innovations. Users access to assistance during the later as well as earlier stages of the change process is always crucial to implementation of innovations involving major changes in

practice. It will be especially important in the case of implementing microcomputers, due to the increasing complexity of learning, to use the innovation over time.

The Carmichael et al. study provides ample documentation of the actual, as opposed to imagined, scope of change for teachers seriously trying to implement the creative learning potential of the NETs. Participating teachers made significant changes in the physical layout of the classroom; in timetabling and classroom management; in altering their own role and behaviors from content expert to guide and co-learner; in structuring opportunities for more active student participation in learning; and in their basic beliefs about teaching and learning.

Some components of the overall change were more difficult than others. The organizational problems (e.g., facilities, scheduling, classroom management) were salient initially, but were resolved by most. The facilities' problems were compounded as additional machines were brought into the target classrooms. Other knotty problems centred on strategies for attending simultaneously to the needs of students on computers and to the rest of the class; dealing with growing disparities in student expertise; adjusting to a different teacher role; and integrating computer activities into the rest of the curriculum.

Teachers needed a full year or more of implementation to figure out how to make it an integral part of classroom activity, and some never really succeeded in reconciling the demands of the regular curriculum with the demands of the computer. Larter et al. (1983) reported that elementary teachers in the Toronto school board found it almost impossible to integrate existing commercial software into the curriculum. The previously cited examples from Lee on the use of DRAW suggest that the availability of materials for use on GEMs has not resolved the complexity of curriculum integration for teachers. The software used in that inservice, however, had been converted for use in GEMs, and were not linked to specific areas of the curriculum. The current generation of programs developed specifically for use on GEMs are targeted more directly at the curriculum and have the potential for easier integration into existing practice. Respondents to a TVO survey of elementary and secondary teachers on the use of microcomputers, however, indicated that 26 per cent of the former

and 50 per cent of the latter have difficulty integrating OESS programs into their lessons (Kwong 1986). This is not a criticism of the materials, but serves to remind us that the difficult of curriculum integration may be alleviated but cannot be solved by curriculum developers for curriculum deliverers.

The Logo study examples illustrate the full blown complexity of implementation, but even these findings may underestimate the problem, because the teachers in that study were highly committed. Other studies indicate that teachers may not always buy into the software potential. Consider this finding from Larter et al.'s (1983) study of the early use of microcomputers and commercial software in Toronto elementary schools.

...in many classrooms pupils are experiencing two modes of instruction - the human teacher and the microcomputer - side by side and with very little overlap between the two. Teachers in these classrooms proceed with their regular activities according to their normal teaching styles and emphasize that microcomputers ill have little impact on their role as teachers; what the pupils do on the microcomputer in these classrooms is quite separate and isolated from everything else.

Given the "stand alone" potential of the technologies, teachers can treat implementation simply as a problem of organizing and scheduling access to machines and software, without getting deeply involved themselves in what students are doing.

Lee's (1986a) analysis of the short-term effects of an intensive inservice program for new users of ICONs and converted software (DRAW EDIT LOGO) adds new wrinkles to our understanding of the complexity of user implementation.

Teacher evaluations showed there was a definite discrepancy between awareness of the potential use and the actual use of computers. In spite of the fact that an overwhelming majority of the teachers indicated that they were aware of the potential use of the computer, over 46 per cent of them were not using the word processing and problem solving programs or did not find these programs suitable for their students at the time of the survey.

Interviews revealed many teachers were unable, unwilling, unprepared, or afraid to teach them to students...

Most of the educational software for the ICON...were not made available to the teachers probably because it was felt that the large number of additional software would only confuse and overwhelm many of the teachers who had not yet managed to use the three programs simply as tools....Evaluation showed that only the simple DRAW program was used extensively by about 83 per cent of the teachers, about half of the teachers made us of EDIT, and only 37 per cent used LOGO.

Of course, the inservice designers did not really expect teachers to master use of the programs with students right off the bat. The inservice was intended to get them started on the incremental path of NET implementation. Lee's observations, however, remind us that high quality initial inservice can help teachers begin to work through the complexities of change, but it does not do away with that complexity. The first quote indicates the difficult developmental leap from knowledge about computer use to actual implementation. Both quotes highlight the varying degree of difficulty teachers experience with different types of software. Example two also directs attention to how little is known about how many software innovations teachers can cope with at once, and how much of the knowledge and skills acquired with one program can be transferred to another. There was a deliberate decision to begin with tool type software in this board, on the assumption that it would make initial use easier than if teachers started out with specific curriculum software. At present, however, there are no comparative research data to suggest what kind of software is easiest to learn with for beginning users of microcomputers. It may be that the perceived relevance of curriculum software outweighs the easy-to-use qualities of tool software from the perspective of teacher commitment to implementation.

Carmichael et al. identified a number of situational factors affecting the difficulty of change for different teachers. Implementation was harder in computer labs than in regular classrooms, and harder for teachers who had only one computer in the class or access to a lab only once a week. It was also more difficult for teachers working under rigid timetables. Teachers already using

activity centred approaches had an easier time integrating the computer into the curriculum and classroom activity than teachers with more structured classrooms. The latter "tended to view the computer as another subject that needed to be scheduled into the timetable".

Students also have difficulty using curriculum software to its full potential. Field test reports of OESS materials, and the Logo study in particular, demonstrate that software often requires entry skills that students do not already have before it can be used effectively. They also show that without close teacher guidance and support materials, students are unlikely to understand and take advantage of the open-ended potential of generative software (despite internal program documentation).

All in all "the teacher as expert implementor" of NET in the classroom comes face to face with all of the issues related to what it means to be a highly effective teacher (see also Berliner (1986) on the "expert pedagogue").

In concluding this summary of implementation complexity at the user level, the comparison of GEMS and OESS materials against 8-bit computers and other systems which do not meet the ministry's functional specifications, and with commercial software, needs to be acknowledged. Much has been made provincially of the superiority of the former in terms of their ease-to-use. A recent TVO survey of elementary teachers on the use of microcomputers does indicate that a majority of the teachers using OESS programs find the ICON versions of OESS materials easier to load and run than the 8-bit versions (Kwong 1986). Deeper implementation, as we have seen, presents many other problems. We realize, of course, that we are discussing the very early stages of NET development in Ontario, but this is the point: our purpose is to highlight these issues, and to figure out and recommend effective strategies for addressing them.

2. Consensus/Conflict

The prospects for successful implementation are greater when those expected to carry out a change agree on the need, on the appropriateness of the innovations selected, and on the priority of the change effort relative to other

local concerns. While educational innovations are often adopted without widespread initial agreement on the need for change and choice of solutions, this does not necessarily spell failure. Teacher acceptance and commitment can develop during implementation when other conditions are favorable (e.g., effective innovations, administrative commitment, adequate assistance). Of course, the consensus of administrators and other stakeholders, such as trustees and parents, is also important.

CONSENSUS/CONFLICT.

Broad perspective: Widespread parent interest and grass-roots supported from a core-group of teachers is seen as representing an important driving force. Teacher attitudes toward technology among the uncommitted (estimated at 80%) teachers is perceived as a tremendous problem. High quality, easy-to-use software combined with student enthusiasm is seen as an important plus. Concerns remain about the incompatibility and relative position of officially sponsored GEMS and OESS vs. other commercial products.

Up close: Evidence exists to confirm the ministry views about grass roots support, reluctance by non-user teachers, and the use of machines and software other than GEMS and OESS. Consensus to the extent it exists can only be superficially meaningful in the absence of experience with concrete, high quality usage.

Consensus/Conflict: Broad Picture

Ministry officials recognize that the general movement towards microcomputer use in education reflects grass-roots interest and initiative. They see widespread parent support for implementation and a core group of teacher supporters. According to their current "guesstimates" (derived from such sources as teacher training statistics), about 20 per cent of the elementary/secondary teacher population are probably enthusiastic or moderately committed computer users. The other 80 per cent are basically "uncommitted" at the present time. In the words of one official, "we still face a tremendous problem with teacher attitudes about use of the technology".

Ministry officials recognize that current non-users are not likely to become sold on the need for using microcomputers solely on the basis of the presumed merits of the technologies. They see this commitment arising from a combination of

parent pressure and access to direct experiences (demonstrations and practice) with technologies that are very easy-to-use and that have immediately beneficial effects on students (e.g., increased motivation to learn, lower discipline problems).

However, agreement on the general need for NET implementation does not imply consensus on the kinds of innovations selected. One interviewee characterized computer enthusiasts as "very passionate about their own views about types of machines, etcetera, to be used". There was a lot of controversy and doubt in the field when the ministry embarked on its plan to sponsor the development of an educational microcomputer and software to support provincial curriculum goals and guidelines. Ministry officials believe that this controversy is dying down now that GEMS and OESS materials have come on to the market and are being well accepted by school personnel. While microcomputers not meeting the Functional Specifications still outnumbered the GEMS machines as of the Fall 1986 (45,250 vs 14,170), the expectation is that GEMS purchases will dominate the market over the next ten years due to their quality, the quality of OESS materials, and continued access to provincial financial subsidies for eligible hardware.

The official policy places the priority on exploiting the creative learning potential of the technologies (rather than limiting use to remediation, drill and content delivery), and hardware and software initiatives support that direction. Ministry policy also favors integration of computer-based learning materials and activities into all subject areas of the curriculum, rather than treating computers and computer applications as a separate course of studies (except in secondary Computer Studies courses).

There is not a clear sense at the level of the ministry of the degree to which teachers and students using microcomputers and software agree with those priorities. There is a fear that implementation could be stymied by entrenched views about the structure of the curriculum and opposition to change.

There are strong mind sets hindering change in the curricula. Over the years, there have been expansions in curriculum content and in clientele, such as special education, but we're used to the traditional

curriculum model. Use of microcomputer technologies suggests a new model. Software integrates the curriculum. It can work against a subject approach.

There is also a sense that parent support for microcomputer use in education is oriented more towards traditional computer literacy goals than towards the use of the computer as a general learning tool, the outcomes of which are highly uncertain (see Community Support).

A final aspect of consensus concerns the relative local priority accorded to NET implementation. Ministry officials are highly sensitive to the fact that continued financial support from the government is critical to accomplishment of its NET implementation goals. The basic approach to maintaining local priority is through special funding, requiring Board implementation plans, doing all possible to make the tools workable and worth the teachers' effort, and tying NET applications into all new provincial curriculum projects. There is an appreciation of the fact that local implementation is always subject to competition for participant time, energy, and organizational resources to meet ongoing demands and other new initiatives. There is little knowledge, however, about the extent to which other local priorities are or are not detracting from NET implementation at present.

Consensus: Up Close

Grass-roots support of the need for microcomputers and educational software in the schools is well-documented. Ministry reports, for example cite the growth in the number of non-subsidized 8-bit microcomputers in the schools from about 5,900 in 1982 to 45,250 in 1986. In a study of the widespread introduction of microcomputers into all but three of the Toronto Board's elementary schools, Larter et al. (1983) found that about 20 per cent of the machines were purchased from funds other than Board funds (e.g., home and school associations), and another 26 per cent from Board funds other than those specifically earmarked for computer acquisition. This rate and the sources of growth are quite independent of the ministry's special initiatives.

Evidence of widespread local parent support is reported in the studies of Larter et al. (1983) and Carmichael et al. (1985), and is described more fully in the up-close analysis of Community Support.

Field data confirm that there is less agreement among teachers than parents on the need for microcomputer implementation. While the 13 teachers participating in Carmichael et al.'s Logo-use study were "a highly committed group", "great reservation" was the most common reaction of non-users in the same nine schools. Among the reasons given for "holding back" were: the view that computers were not part of the established curriculum; a disbelief in the potential advantage; value conflict; the sense that personal concerns and costs outweigh the benefits; belief that computers are just another fad. Larter et al. reported similarly negative dispositions and fears among many teachers, but they also found a general acceptance among non-users that microcomputer use in education is inevitable.

An important message from the field is that mere availability and access to the technologies is not sufficient to create "the need" to implement among non-users. Carmichael et al. for example, describe a school where the experimental teacher's peers ignored what she was doing until parents initiated fund raising drive for microcomputers. Overall, however, the researchers reported that the reservations of other teachers in most schools eased by the end of the initial project year. In her microcomputer inservice study, Lee (1986a) concluded that "it is irrelevant whether or not teachers attend the inservice voluntarily, the fact remained that almost all teachers who took the inservice training made an attempt to teach their students in the computer lab" during the first year of implementation. In one of our interviews, an OISE researcher offered a similar report:

People are supposed to be volunteer users. Because materials and training are provided, teachers see it as compulsory. But the effect is that most teachers see the value of it after initial training and support.

Lee (1986b) did a follow-up study in four schools during the school year after completion of the initial board-wide inservice cycle. Most teachers in two of

the schools were actively using their scheduled times in the microcomputer labs, while teachers in the other two schools were, with the exception of a few individuals, not frequent users. Lee found that the variation in degree of use could not be explained by differences in administrative pressure and support, location of the computer lab, software availability, the computer lab schedule, teacher background (sex, age, prior experience with computers) and students. The main factor that seemed to be contributing to uniformly high use among teachers in a school were school wide consensus on the importance of NET use for students, and the amount of teacher-teacher collaboration in helping each other learn, in solving facilities and scheduling problems, and in coordinating lab use to ensure maximum utilization at all times.

From these data we conclude that a willingness to act on "the need" is more likely to come as a result of such factors as parent pressure, staff consensus on the need and importance of implementation, ongoing collaboration with other users in the same setting, and/or a mandate to implement coupled with adequate materials and training.

There are clearly some highly interested and committed teachers out there, such as those participating in the Logo-use study. The "implementation mode" used in that project provided no formal training, no consultative assistance, no peer support and no extra incentives or release from other demands. The successes in that study were evidently due to the competence and commitment of the teachers and to the quality of the Logo program. Clearly such a model of "unsupported implementation" could not be generalized to less committed teachers using highly uncertain software. It is also evident from findings in that project that other teachers cannot be expected to easily fall in line with the early innovators.

The willing participation of students is essential to implementation of microcomputers in education. Field data thus far generally confirm that students demonstrate a high degree of acceptance of the need to learn about and with microcomputers and software.

Field data on the current degree of consensus about hardware and software choices and uses can only be inferred from available statistics on the hardware

installed base and software use. The ministry began gathering statistics on numbers and types of microcomputer systems in schools in September 1986. Of 45,250 first generation 8-bit systems in place, Commodore C64s, Commodore PETS, and Apple IIs dominated the market. Among 14,170 second generation 16-bit systems in the schools, the ICONs clearly outnumbered the IBM system which only became eligible for ministry subsidies during 1986. About 2,240 "other systems" were also reported (e.g., Apple Macintosh, Commodore Amigo). The 1986 TVOntario teacher surveys testify to the continuing variety of hardware in the schools (Kwong 1986).

(Elementary teacher - N = 709) Over half the current users (52 per cent) reported using the Commodore 64. It is followed by the Apple (29 per cent) and the PET (23 per cent). Fifteen per cent have used the ICON microcomputer recently acquired by schools.

(Secondary teachers - N = 225) Forty per cent of current users reported having used the PET microcomputers. It is followed by the Commodore 64 (35 per cent) and the Apple (31 per cent). Thirty per cent have used the ICON microcomputer recently acquired by the schools.

Thirty-seven per cent of elementary school software users and 25 per cent of their secondary counterparts said they used the OESS programs. The continued presence of various non-compatible types of equipment and materials was one of the reasons given for non-adoption by non-users in the Logo study. In schools with a great variety of non-compatible models and little co-ordination in use, Carmichale et al. (1985) found people arguing over the allocation of funds as opposed to pedagogical issues.

As we have noted there are indications that the current direction of hardware/software acquisition may indeed be favoring GEMS and OESS materials. Gillis' reports on field trials of OESS materials indicate a positive response to both by users. Lee (1986a) reports that her Board discontinued the purchase of PETS concurrent with the acquisition of 700 ICONs. The previously mentioned OISE field researcher reported that the more exposure teachers get to the ICON, the more they like it. She added, however, that the ministry's involvement in developing an education microcomputer "is still a hot

argument in the schools among ordinary teachers" and that "many people in the field do not see why that money is not spent on developing software for machines that already existed".

Technical superiority and government subsidies notwithstanding, school board level consensus on the selection of hardware (and related software) is not guaranteed. One of our OISE interviewees, for example, suggested that large wealthy school boards actually have less financial incentive to purchase the expensive GEMS than small boards because their grant rate is much lower. Recall too that many of the current users are early adopters and are enthusiastic about what they have been doing, and the equipment materials they have been using. Local support groups for users of similar equipment have evolved, as well. The willingness of these early enthusiasts to change over to GEMS cannot be assumed, although incentives are apparently stimulating some changeovers. Planned or unplanned restrictions on supplies and resources also come into play. Lee (1986a) reports the side effects of concurrent decisions by Commodore Business Machines to discontinue production of 4032 PETS and by the Board to redirect the bulk of its support to the purchase of GEMS (ICONS). A board-wide PET user newspaper closed down, and the local PET Software Evaluation Committee ceased to exist and acquire new programs for the PET. A planned board-wide inservice to support PET use was redesigned and carried out with ICONS. Lee concludes that continued use of PETs by teachers was doubtful without continued support for new software or other resources and encouragement.

The field data reviewed also suggest that creative learning and curriculum integration are not accurate descriptors of the past and present situation. Larter et al. (1983) report a lack of consensus at the school level on what to teach pupils about microcomputers, the functions the machines should play and the methods of using them. Only 11 per cent of the 115 elementary schools in the study said they were using microcomputers for subject teaching. More prevalent uses included computer programming (37 per cent), remediation (31 per cent), drill (26 per cent), games (25 per cent), and general enrichment (24 per cent). In the 1986 TVOntario surveys, only 11 per cent of the elementary and 27 per cent of the secondary school users said they used the programs as an integral part of a lesson. The other major uses recorded were "to supplement a lesson" (57 per

cent elementary, 56 per cent secondary) and "as a remedial tool in a lesson" (39 per cent elementary, 32 per cent secondary).

It seems that the existing uses of microcomputers and software may be well entrenched for many current users. The availability of more exciting curriculum-relevant but open-ended software may not suffice to stimulate change. Furthermore, for most non-users, the existing uses are the nearest role models of acceptable and workable practice at the school level, and may hinder their ability to envision the generative potential of OESS materials. While the kind of software teachers are using dictates, to a certain extent, the uses being made, it is evident from the previously cited findings of Gillis (1985, 1986) and Lee (1986a) that teachers and students can use OESS materials without fully understanding or exploiting their potential.

Field data also indicate that other priorities at the school level can work against successful implementation. Carmichael et al. (1986) provide graphic accounts of the difficulties teachers in their study had copying with pressures to satisfy the regular demands of the curriculum timetable. A few actually discontinued implementation because they were unable to justify to themselves the time needed initially for computer use. Others felt less locked in to the timetable.

The teachers who were able to integrate the computer into the daily routine of the classroom were willing to suspend, at the outset, some of the needs of the regular curriculum, so that they and their students could learn about Logo and about how computers could best serve their needs.

The pressure was not just self-imposed. The researchers documented the additional pressure that users felt from other teachers in the school to conform to existing curriculum structures. In her follow-up study of microcomputer use following an intensive inservice program in four schools, Lee (1986b) illustrates how teacher allegiance to other priorities worked against high utilization of the microcomputer lab in one school.

On two separate occasions, I was at St. Quinta and observed that all computers were turned on, and stayed on, for the full day without anyone coming to use the lab. This was in spite of the fact that all

four computer periods on both days were booked as indicated on the schedule. Some probing discovered that two of the teachers were away on those days. One wanted to complete an art lesson. One said she was busy doing something else, but really meant to tell someone about the freed up computer time. One was planning on attending an important meeting at the end of the day and had to leave a few minutes early, but was so busy all day that she did not get around to telling anyone. One decided at the last minute to watch a video with another class. One simply forgot she had signed up for computers.

Even in one of the high use schools where microcomputer implementation was given high priority by most teachers, the presence of other unavoidable priorities hindered full implementation by some teachers. Grade 8 teachers, for example, had a hard time using the lab when scheduled because of such things as conflict with the rotary timetable, the need for time to prepare students for Confirmation (this was a Catholic School Board) and for Grade 8 examinations (Lee 1986b). The net result was non-use for the teachers, and for some, the learning gained from the initial inservice was lost. The message here is that other priorities are not to be ignored or done away with. They have to be accommodated without losing sight or sense of the importance of implementation of the NETs.

Finally, Larter et al. (1983) reported that lack of consensus on the priority for microcomputers vs. other needs and expenditures was one of the obstacles to implementing NET.

What can we conclude from this "up close" analysis of consensus about NET implementation? First, teachers are presently divided into "enthusiastic pioneers", and "non-users" who have varying degrees of reluctance. But a combination of parent administrative, and peer pressure, coupled with positive initial user experiences and adequate support, can overcome initial reservations about the need for change. Second, traditional and non-flexible curriculum structures and norms can be a powerful deterrent to implementation when new users start trying to change. Third, the use of machines and software other than GEMS and OESS materials has already become routinized within the current user population, and may be more difficult to alter than anticipated. Prior

success with other equipment and materials may also set local examples of good practice which are at odds with the ministry's implementation goals. Fourth, consensus on the choice of machines and software is probably as dependent on funding levels and continued access to supplies as it is on product quality. Finally, consensus, to the extent it currently exists, can only be superficially meaningful in the absence of experiences with concrete, high quality usage.

3. Quality/Practicality

Innovations are more likely to get implemented and stay implemented when they result in visibly improved student outcomes. Thus, the chances for successful change are greater when the technical certainty of the innovations is already known, and when at least some of the benefits for students are immediately apparent to teachers. If the impact of the innovation is uncertain, its success may depend on careful implementation and monitoring of effects and innovation modification during implementation. Achieving good and relatively immediate student results is one of the keys to developing commitment to change on the part of initially skeptical teachers.

Innovations quality for implementation is also a matter of how "practical" the innovation seems to the teachers attempting to change. Practical innovations are those that address salient student/teacher needs, that fit well with the teacher's situation (e.g., students, organizational setting, curriculum), and that include or result in concrete how-to-do-it information. Practical does not necessarily mean "easy". But it does mean the presence of concrete next steps toward greater and more sophisticated implementation.

The practicality of innovations also depends on the trade-off between the personal costs (time, effort, etc.) and actual benefits of getting and staying involved, and is closely tied to the implementing organization's (school board, school) capacity and support for change. If the board does not provide the necessary resources and support, those expected to implement the change are likely to dismiss it as impractical - no matter how much potential it seems to have.

Innovations that are procedurally vague and do not initially fit the teacher's situation well, must become increasingly "practical" during implementation. This implies ongoing development and adaptation of the innovation during the implementation phase, and starting with manageable chunks and building on them. The danger is that the quality of the innovation can easily be sacrificed in the interest of minimizing the difficulties of putting it into practice.

QUALITY/PRACTICALITY.

Broad picture: Concerns about quality of first generation machines and software and about equal access were major factors motivating the ministry's 1981 decision to get involved in a big way in NET. Uncertainty exists about the impact of NET on learning outcomes. Unavailability of practical clear models of classroom implementation is acknowledged, as well as the new personal and financial demands that are being placed on individuals and systems. Software development according to specifications, and a corresponding dissemination and feedback system is expected to address some of these concerns.

Up close: Field data confirm most of the issues just cited. Lack of access to software is one major problem. Another obstacle is difficulty in managing and learning how to use programs, and how to incorporate them into the curriculum. Student interest is experienced as high, but the impact on learning is unknown. Access and time for teachers to plan and practice on the GEMS is severely limited.

Quality/Practicality: Broad Picture

Concerns about the quality of first generation microcomputers and commercially produced educational software were major factors motivating the ministry's 1981 decision to get involved in NET development and implementation. Existing 8-bit computers (e.g., Apple IIs, PETs) were not designed with the needs of educators in mind and were thought to be incapable of supporting the kind of software needed for complex learning objectives in the curriculum. Evaluations of the educational value and curriculum alignment of commercial software were largely negative. The quality of hardware and software varied greatly as did the choice of products between and within school boards, thus creating a problem of equal access. Hence, the ministry's decision

to support the development of an educational microcomputer, the development of software for that type of machine keyed to provincial curriculum goals, and distribution mechanisms to ensure equal access. Product quality is maximized through the development of standards for hardware/software development. Equal access is maximized by providing equalization grants to support purchases of ministry approved hardware, by purchasing provincial licenses for software duplication and use, and by distributing sample copies of software to all boards through the TVO Ontario Educational Software Service.

Ministry officials recognize that learning to use the machines and software represents a stumbling block for many teachers. A major thrust of the hardware/software development policies is to make the materials as easy-to-use as possible. The idea is that teachers and students would not have to know a lot about the technologies to be able to use them as learning tools. Until that level of technical sophistication is actually achieved, teachers need to know how to solve minor technical problems or have immediate access to someone who can.

A related issue concerns the continuing variability and incompatibility of existing hardware and software in the school systems. Users can hardly see implementation as "practical" if they cannot transfer what they learn about using one branch of computer and piece of software to another. The ministry's solution is to attempt to create a situation where machines and software have a consistent environment, i.e., to make the software portable from one machine to another. Functional specifications for hardware development is the key strategy. The Stage I specifications did not do the trick because programs for the two types of GEMS now on the market are not portable to each other. Stage II specifications are intended to ensure compatibility between different types and generations of GEMS.

While the ministry is doing its best to maximize the quality of software produced for use on GEMS, officials acknowledge a continuing uncertainty about ease-of-use and student impact. Attempts to reduce this uncertainty include the collection and analysis of field test data, dissemination of findings to software developers, setting up a technical assistance centre at the Ontario Institute for Studies in Education for developers, and maintaining hot-lines through OESS to identify bugs and problems in software and its use.

The uncertainty surrounding learning outcomes is a focal concern. Ministry officials strongly believe that use of technologies can result in improvements in such things as content mastery, thinking skills, problem solving skills and student attitudes towards learning. At the same time, they admit that actual learning outcomes of the creative use of open-ended software are not well-in-hand. The positive attitudes of students to the introduction of microcomputer use in the schools have been well-documented, but that does not speak clearly to cognitive outcomes. The hope is that high student interest will make implementation seem more useful and worth the effort for teachers.

In talking about teachers' use, ministry officials mark a clear distinction between learning to use microcomputers and software for oneself, and learning to use them in a worthwhile way in the curriculum and classroom. The practicality of user implementation is currently hindered by a high degree of uncertainty about how to best organize and use the new educational technologies to support the accomplishment of provincial curriculum goals. The "how-to" question is being dealt with at the front end by requiring software developers to include supplementary documentation in the programs. The current need for inservice and support materials focusing on instructional applications of GEMS and OESS materials is considered a high priority. Looking down the implementation road, officials talk of the need to foster variation in use, to get research on effective practices, and to feed that information back into the user system. Some think in terms of the possibilities of creating microcomputer-based communications networks to enable users to interact with each other about implementation concerns.

The software development policies and specifications are intended to ensure a good "fit"⁽²⁾ between OESS materials and the Ontario curriculum. In principle, this should increase their practical value to teachers and the likelihood of implementation. But technical alignment of the machines and software to provincial curriculum goals does not imply practical alignment to existing classroom organization and teaching practices. In our interviews ministry

2 "Fit" with classroom organization and teaching.

officials spoke about numerous changes in traditional models of classroom organization, teaching, and evaluation, particularly at the secondary level.

One of the biggest things is that it changes the nature of classroom interaction and makes it a more child-centred environment.

The required model of teaching doesn't fit well with the teacher at the blackboard content delivery model.

Elementary teachers are more used to working with kids in groups on different tasks....Computers fit into that type of situation nicely.

"Fit" with pupil evaluation practices

Creative use doesn't jibe with the established reporting procedures. I think that's one of the biggest reasons teachers don't implement. They are so locked into required reporting by specific numbers and having to justify it....Using the new software programs, you can't evaluate in the same way as quantitative tests.

"Fit" with curriculum scope and sequence

Kids moving ahead at different rates. What happens when a kid finishes Grade 6 topics too early? It upsets the sociology of the school. Schools are not set up to cope with the reality of individual progress.

"Fit" with staff evaluation practices

How is the principal going to evaluate learning in the classroom? All his models of good teachers may go down the tubes.

"Fit" with existing responsibilities and time-use

There is no question that something is being added to the teachers' workload. And the teacher has to have time to learn about a program and how to incorporate it into daily activities.

In sum, there is a sense that a good initial fit between the innovation and local organizational conditions is unlikely. This situation is regarded both as a challenge and as a possible obstacle to implementation.

The practicality of implementation is clearly linked to questions of organizational feasibility, particularly the availability and access to hardware, software and money. In the grand scheme of things, the ministry has held off from mounting a provincial implementation initiative until the "installed base" of GEMS and OESS materials was large enough to make it worthwhile. As of September 1986, the installed base of GEMS was 14,170 (projected goal 180,000) and the number of software items approved and distributed through OESS was approximately 80 (target of 830). Ministry officials believe now is the appropriate time to bring attention to bear on implementation.

Local access to a "critical mass" of hardware and software is seen as a major issue.

You won't get people enthusiastic about a technology they don't have.... The matter of building up an installed base in the school to make it worthwhile to use them.... I'm not sure if one computer in the classroom or once a week is worth the effort.

If you have enough microcomputers in a class, three or four, and enough software for the teachers to see that it will make a difference, then I think it is worth their time and energy. If teachers don't see that they can use it well enough to make a difference they won't do it.

These problems reflect at the school level because unless the hardware and software are there, there is no trigger for action.... It is frustrating for teachers who want to use it but have insufficient access.

Current inequities in access within school are said to create competition and frustration among teachers in some cases, and new patterns and norms of co-operation in others.

The key to building the hardware base is continued and expanded provincial subsidies for GEMS purchases. Although there has been a steady growth in provincial allocations to subsidize GEMS purchases, from \$16 Million in 1984/85 to \$31.5 Million for 1987/88, the level of ministry funding is subject to annual budget deliberations. The achievement of the desired "critical mass" of hardware (one microcomputer to ten students) is clearly a long-term effort. There appears to be less a problem in reaching the software development goals over the next several years. Still there is recognition that it will be another year or two before there is really enough software to make it worthwhile to expect some implementation across the curriculum at all grade levels. In the meantime, the lack of suitable software for specific areas of the curriculum remains an obstacle (real and perceived) to the practicality of implementation for many teachers.

According to ministry sources, lack of access to appropriate software is a matter of dissemination as well as development. While the problem of getting the new software from the ministry to the boards has been solved through the licencing provisions and the creation of OESS at TVOntario, ministry officials have discovered that administration and support staff in some school boards are restricting teacher access to the software and related information (e.g., software catalogues). Thus, teachers in some boards may reject GEMS implementation as impractical due to local decisions about what, when and how disseminate software materials. Finally, we should caution that access to good hardware and software is only one, albeit critical, step toward effective use.

Quality/Practicality: Up Close

Data from the field provide varying degrees of confirmation of most of the issues of innovation quality and practicality anticipated in the preceding account.

Hardware quality does not surface as a major issue in the studies of microcomputer use from the pre-GEMS era, though the 1983 Pilot Schools Project did document some complaints about the limited memory capacity of conventional microcomputer systems and the greater efficiency of disk drives

over cassettes. A more critical issue was lack of quick access to repair services and the resulting time loss, but that is not a function of the machines per se.

It is interesting to note that the issue of storage capacity has not been eliminated by the introduction of GEMS, as indicated in comments from an OISE researcher.

At the moment with the 10 megabyte fileserver storage capacity there is not enough space to store Ambience and other materials. So there is fileserver competition in the secondary schools. Schools will either have to buy more fileservers or a fileserver with greater storage capacity will have to be created.

While our data are sketchy, field tests on the use of OESS materials GEMS, and our interviews with OISE researcher do not indicate major problems with the technical quality of the new systems.

The presumed disincentive to implementation created by continuing product variability and incompatibility exists, but perhaps not as strongly as suspected. Carmichael et al. (1985) cite hardware/software variability as only one of several reasons for non-implementation given by non-users. And some teachers implementing Logo in their study questions the practical value of their participation on account of the uncertain generalizability of their implementation experience to other programs and machines. Problems resulting from hardware variability were not found in the five Pilot School Projects, though it should be noted that there was less within school variability than across school variation in hardware types. For the present, the portability issue may be more a macro-level than a micro-level implementation concern. It should be noted, though, that the introduction of GEMS equipment and software heightens the portability problem from school to the home. Teachers and students are not able to practice and work with the materials on compatible home computer systems.

There is evidence to substantiate the ministry's early concerns about the quality of commercially developed software, and its negative consequences for implementation. Larter et al. (1983) cite teacher complaints about the low

quality and poor curriculum fit of most software, the near impossibility of integration into the curriculum, the lack of subject relevance, inappropriate language and "bugs" in the programs. A 1982 Provincial Review Report on microcomputer use and the Pilot School Projects report also document problems of quality with commercially developed software, particularly its relevance and fit to the curriculum.

The question of software quality has been addressed but not resolved by the ministry's software development initiatives. Uncertainty about the characteristics of effective curriculum software affected implementation of OESS materials in field trial situations. Pike (1985) reports that many bugs in the Exemplary Lessonware Project programs were not spotted prior to the field tests. Gillis (1985; 1986) identifies a number of program characteristics that hinder effectiveness of implementation -- e.g., over reliance on written instructions and help-screens, lack of try-out options, segregated tasks and ideas, unclear programs. Pike and Gillis both highlight the failure of software developers to predict students capabilities for using the materials. Some student characteristics hindering effective implementation include lack of entry skills/knowledge, age, general ability level, preference for impulsive behaviour over reflective thought, impatience with written instructions, and an inability to understand the potential of programs without close guidance and supervision. This last finding is particularly important since the practicality of implementing these programs with large numbers of students depends in large measure on their stand-alone potential. In general the data reaffirm the value of careful field testing of new software. But they also serve as clear reminders that the OESS materials are not coming into the schools as definitively tried and true innovations, regardless of the benefits of the mini-field tests.

Carmichael et al. (1985) provide detailed documentation of positive student outcomes resulting from implementation of Logo-use in 13 classrooms. But Logo is a reasonably well proven program, and their findings cannot simply be extrapolated to any creative use type software. Teachers responding to TVOntario's 1986 surveys of microcomputer use gave good marks to OESS materials. Seventy-five percent of the elementary users and 57% of the secondary users rated the programs excellent or good. Pike reached a more sobering conclusion based on her analysis of field tests from the Exemplary

Lessonware Project (which consisted of many of the same programs referred to in the TVOntario study):

The pilot projects produced no learning miracles...There is nothing to suggest that computer instruction of the sort tested in this project did or might lead to any fundamental changes in thinking skills, learning styles or general ability....It was obvious that we had not yet learned to exploit fully the teaching potential of computers.

Pike also found that software emphasizing knowledge acquisition as opposed to learning skills, and content review as opposed to presentation or exploration, was more successful than more sophisticated problem solving, open-ended, simulation type software. This finding is a daunting one for ministry hopes for "creative" computer use.

All this is not to say that positive and observable learning outcomes are not obtainable from materials developed for use on GEMS. But it does suggest that immediate results on the cognitive side of learning may not be readily apparent to teachers undertaking implementation.

On the other hand, positive results in terms of student motivation, confidence and enjoyment have been consistently documented for both commercially developed and OESS materials (Larter et al., 1983; Report on the Pilot School Projects 1983; Carmichael et al., 1985; Pike 1985; Gillis 1985, 1986). Thus, the success of implementation may be enhanced in the short run by high student interest. But the long term continuation of implementation may depend on further evidence of actual gains in learning in comparison to other teaching methods.

Whereas problems in learning how to use the hardware do not appear as a major obstacle during implementation, problems in learning how to use programs and how to incorporate them into the curriculum and classroom activity do. The teachers' need for practical information on how-to-do-it and how-to-use-it is consistently reported, no matter what types of machines and software are used. Conventional approaches to this dilemma have fallen short. Larter et al. found many teachers unable or unwilling to learn from written material on the screen.

Gillis and Pike document similar difficulties of teachers and students in learning what to do with OESS materials. As reflected in the following quote from an OISE researcher, the ineffectiveness of internal program documentation for teachers is linked to organizational and technical constraints limiting access to the information.

A difficulty arising from the ministry philosophy of including electronic documentation on the disks is that it makes it harder for teachers to gain experience with the programs. They have no supportive print materials on the programs that they can take home and study and think through in trying to work out how they could use the programs in the classroom. They have to be on the computer to get access to the information they need to be able to use it in the classroom.

The first wave of programs distributed through OESS for 8-bit computers were accompanied by user manuals. Respondents to the 1986 TVOntario surveys found them helpful and easy to use but lacking in sufficient "utilization ideas and curriculum applications". TVOntario survey respondents also criticised most inservice activities as lacking in "practical examples" for software use. In sum, field data indicate that effective implementation strategies will have to focus on the practical problems of helping teachers figure out what software can do and how it can be used in the classroom.

Field data also generally confirm the kinds of issues relating to the "fit" or NET implementation to local curriculum and organizational conditions reported by ministry sources. Major constraints can be imposed by local curriculum structures and norms. Carmichael et al. (1985) described how teachers efforts to implement Logo were hindered and even diminished by inflexible timetables and the expectations of other teachers as to what content should be covered when. One of the OISE researchers interviewed in our study reported that the unpredictability of what kids learn with open-ended software was a source of conflict in schools where she was working. In one case she found a situation where people were banking software to make sure that children did not see it until the content appeared in the curriculum.

The Carmichale et al. study provides the best available information on the problems associated with fitting NET use into the organizational structure of the classroom. As pointed out in previous sections of this report, they found that teachers who succeeded had to make major changes in timetabling and classroom arrangements on a trial and error basis during implementation. Teachers in that study had considerable difficulty trying to provide individual attention to students on the computers because of class size, especially in computer labs. Some teachers and students had a hard time adjusting to new classroom arrangements which placed students closer to each other and led to more noise and more moving about the room. All in all, it is likely that using NET increases teachers workload in the short run, as they attempt to sort out the management, instructional and student monitoring problems; counterbalancing the increase in workload is high student and teacher interest and motivation.

In her inservice follow-up study of microcomputer use in four elementary schools, Lee (1986b) documented the trials of trying to find or create appropriate space for microcomputer labs. Interestingly, a seemingly good location (e.g., ample space, quiet, non-disruptive of other teachers) did not guarantee high use, and a seemingly poor location (e.g., crowding, noise level, interference with and from other teachers' activities) did not necessarily spell low use. All the schools had trouble finding a suitable location. One of the low use schools set up the lab in one-half of a noisy gym and left it there. Another low use school put it in an upstairs section of the library. After continual complaints about noise from the librarian, a new wall had to be put in to block the noise. The "quite" lab was no more used than before. One of the high use schools was suffering from overcrowding, and had to put the lab in the library, which also housed a temporary class and regular library use activities. There was a lot of noise and people moving around, but the lab remained in use almost all the time, and the teachers worked out creative ways of reducing the number of bodies and activities going on in the library at any one time. In the other high use school, the lab moved from cramped quarters in a library hallway to equally cramped quarters in half of a basement classroom, before an unexpected decline in enrolment freed up a regular classroom. Lee's data indicate that for lab configurations, facilities problems are to be expected, and how much these problems work against implementation depends on the presence or absence of

other factors--e.g., staff consensus on the priority and need for implementation, and staff collaboration in working out solutions to the problems.

One of the most difficult organizational and individual problems with the practicality of implementation is the consistently reported need of teachers for time to learn what programs can do and time to plan how they might be used. This was documented in all the sources consulted. The current dilemma for teachers is well captured in this quote from an interview with an OISE researcher.

Not only are teachers busy in school, but computers are busy in school. Teachers don't have time during the school day to work on them. And when they do have the time the computers may not be accessible. The system forces people to learn on their own. And the ICON can't be taken home to practice when time is available.

It is not clear from the data at our disposal the extent to which access to hardware continues to hinder implementation from the user perspective, as reported in the early studies of Larter et al. (1983), the 1982 Provincial Review Report and the 1983 Pilot School Projects Report. Respondents to the 1986 TVOntario survey indicate that the majority of users have no problem with the availability of equipment. Only 15% of the elementary and 12% of the secondary school users said that the microcomputers in their schools were overbooked. Of course, this may simply reflect the small size of the user population at the time. A reported negative side effect of insufficient numbers of computers in the classroom is that teachers have double work in preparing double activities. The Logo-use study, however, suggests that this is more a function of how well the teacher integrates computer use into the curriculum than of the number of machines. As we have seen, such integration is difficult.

Lack of access to software or software of appropriate quality was cited as a major obstacle to implementation in the Pilot School Projects Report in 1983. The development and distribution of new software under ministry initiative since 1983 has not entirely alleviated the practical constraints imposed on teachers by limited software availability. Now the issue is not software in general, but software for use on GEMS. A Board studied by one of the OISE researchers

interviewed, for example, bought Commodores rather than ICONS for their elementary schools because software for the ICON was not available at the time. While more and more software for GEMS is coming out, information about the programs and access to them is not necessarily filtering down from Board contact people to teachers in the schools. TVOntario survey figures give some indication of the breadth of the problem. Although OESS has been in existence since May 1984, only 43% of the elementary software users (N = 709) and 41% of the secondary software users (N = 275) answering the survey were aware of the service, and only 37% and 25% respectively had used them (even though the first batch of OESS programs were developed for use on 8-bit machines as well as ICONS).

A final local issue bearing on the practicality of implementation concerns the hidden costs of implementation. Larter et al. (1983) cited the unexpected financial demands of installation, maintenance, books/manuals, repairs, consultants, and so on. The OISE field researcher referred to above found that principals "always have to put in some school money" and that "most money comes from things like the school supply budget."

B LOCAL CONDITIONS

We have spent considerable time on examining factors 1 - 3 of Table 2, because they refer to NET itself. It is essential to understand first, what kind of innovation we have on our hands. The remaining seven factors (see Table 2) refer to the local conditions, procedures and processes that make it more or less likely that continuous attention and support will be directed to NET prior to, and especially as it is being implemented (see Fullan 1985; Huberman and Miles 1984). There is strong evidence to show that the following seven factors influence the degree and quality of implementation:

- Central office direction, support, and commitment
- Process for implementation and institutionalization
- Professional development and assistance
- Implementation monitoring and problem solving
- Principal's leadership

- Community support
- Environmental stability

As before, we provide a brief statement to clarify the factor, followed by an attempt to compare perspectives and experiences from the "broad picture" with those "up close".

4. Central Office Direction, Commitment and Support

The commitment and actions of central office administrators are critical to the success of board-wide implementation efforts. General endorsement and verbal support do not suffice. Teachers and principals are unlikely to invest the effort needed if central administrators do not demonstrate with actions as well as words that they take the change seriously.

Central administrators have a key responsibility initially to help confirm and clarify the need for change. Implementation is more likely to happen when there is clear consistent communication and pressure from the administration, both initially and during implementation. While there may be latitude for adaptation and variation in use, administrative direction should give priority to the quality not the ease of implementation, otherwise most innovations will be "downsized" or adapted away.

Administrative pressure must be accompanied by assistance. The message should be "we are going to do it right, and we'll help you". Assistance requires adequate resources for training, consultative help, release time, materials etc. throughout the change effort (see factor 6, Professional Development). It means targeting these resources on the implementation requirements and on specific problems. It also means establishing clear responsibility for managing and facilitating the change effort at the board and school levels. The seriousness of administrative intent is perhaps most usefully demonstrated when teachers see real efforts being made to identify and resolve problems arising during implementation, and real recognition being given to those who progress in making the change.

Administrative attention to the policy, resource and training requirements for institutionalizing a change are essential to the continuation of new practices if and when they get into place. This should begin during the implementation phase of the change. This point is further clarified in the following section.

Whether the change is system-wide or just within a particular school, it helps to have a friend in court (someone in the central office in this case) who has power, who thinks the innovation is important, and who will fight not just to get it approved, but to see that ongoing resource needs and problems arising during implementation are addressed. Whoever plays the advocate role must have good communications with people directly involved in facilitating and using the innovation in the field.

CENTRAL OFFICE DIRECTION, COMMITMENT AND SUPPORT.

Broad picture: School boards are spending a lot of money to get hardware and software in place. Local policy choices are often not consistent with provincial goals, due to product variability and poor understanding of the technology. Provincial hardware initiatives are beginning to guide local purchases. Distribution of the new software is breaking down at the school board level. Local authorities should pressure teachers to implement, and give support and recognition for trying out different uses.

Up close: Early NET implementation in school boards was characterized by general support from the central office, but lack of policy direction and coordination of effort. Active support from central office is needed initially and during implementation. Teachers are often unaware of Board policies and plans. The shift to GEMS is influenced by local choices about OESS materials distribution. Latitude to experiment with variations in use creates anxiety about accountability for some teachers.

Central Office Direction, Commitment and Support: Broad Picture

According to ministry officials, most Ontario school systems have already made a substantial financial commitment to the acquisition of microcomputer hardware and software. One cited a private contractor's estimate that "school

boards would spend over 800 million dollars on information technology over the next ten years if we did nothing without central direction."

The flip side of the coin is the belief that these funds are not necessarily being spent wisely or in the best interests of provincial goals for education. In particular, the goal of equal education opportunity is jeopardized by the acquisition of microcomputer systems and software of varying make and quality. Without ministry intervention, it is claimed, there would be little incentive to standardize the software environment for different brands and generations of hardware, and the production view is that the boards are willing to spend the money to get direction of technological development in line with the needs and goals of the education system.

The problem, as viewed from the perspective of the ministry, is compounded at the school board level by insufficient understanding of the full potential of the technology for use in education, a lack of clear policy vision, and confusion in choosing between alternative products and uses. An underlying concern is that the support of school system authorities for NET implementation may be oriented more towards conventional computer literacy and drill and practice type uses than towards the creative use of computers as a personal learning tool across the curriculum. Thus, proposals for stepped up public awareness efforts include dissemination to school trustees and officials, in addition to teachers and parents.

There is a clear expectation that the availability of substantial grants to subsidize acquisition of ministry approved microcomputer systems will, in fact, influence the direction of decision-making by local school system authorities. That annual requests for grants have far exceeded the availability of funds suggests that the strategy is working at that level.

There is considerable uncertainty, however, about what school system officials are thinking and doing about the software available for use on GEMS. As elsewhere indicated, feedback from the field indicates that administrators and support staff in some boards are not distributing all the OESS materials and information to their schools (see Quality/Practicality).

Apart from making the technology available, and facilitating access to professional development and consultative assistance, ministry officials believe that school system authorities should work on creating a supportive climate for adaptive implementation:

With the new technology there is a need for latitude for risk taking, experimentation, being supportive...

There has to be a climate that says to the teacher that they are doing a good job and that they are expected to spend time on it. There needs to be a kind of informal reward structure for teachers. These are things that senior administrators can do, including principals. I don't mean money. Rather, setting the climate so things are seen in a positive light.

The picture is one of pressure, but pressure combined with encouragement, support and recognition for trying out different ways of using the innovation. There is a less explicit expectation that school board officials will be receptive to changes in such things as curriculum structure and timetables, classroom organization, teacher roles and pupil evaluation/reporting methods arising from school-level experimentation.

Central Office Direction Commitment and Support: Up Close

The 1982 Provincial Review Report on Instructional Use of Computers stated that "most boards do not have policy statements for computers, but many have computer committees that are developing recommendations". Despite the policy gap, case studies of twelve boards across the province revealed considerable early support from boards for hardware/software acquisition and teacher access to professional development. Central support was typically a response to initiatives undertaken initially by enthusiastic teachers/parents; though plans for diffusion of the technology beyond the initial core of users, particularly at the elementary level, were underway in many of the settings examined. Considerations of equal access had more priority than pedagogical effectiveness in deciding on the placement of new machines and software. Where policies existed, the emphasis was more on computer awareness and

literacy goals than on using the computer as a learning tool. The direct actions of central administration to support implementation were not described in the Report. Responsibility for computer related incentives was typically delegated to newly appointed computer resource personnel or central committees.

In their study of the introduction of microcomputers in Toronto elementary schools, Larter et al. (1983) report a similar pattern of general support from the central office for grass roots microcomputer adoption and use, without specific policy directions to guide utilization and implementation assistance. Many teachers were frustrated by the absence of clear system-level expectations for microcomputer adoption and use. Individual schools were basically doing their own thing. At the board level several departments were involved with hardware and/or software, but their responsibilities were ill-defined and there was little overall coordination of efforts. As a result, some teacher needs were not being met. Presumably, the lack of local policy directions observed in these early studies has changed given the increase in microcomputers in the schools since 1982.

Other early studies of implementation, such as the Pilot School Project and the Logo-use study, focussed on special projects involving teachers in individual schools. They do not give much insight into system-wide policies and support for NET adoption and implementation in the participating boards.

Lee's (1986a) description and evaluation of a board-wide computer in-service program for elementary teachers provides a more recent picture of central office direction and support for implementation. The Board invested a lot of money in new equipment (700 ICONS) support personnel (Coordinator, consultants), and support materials (manuals) in conjunction with the in-service. Participation was voluntary. Lee attributes the high participation rate (95%) in large measure to administrative pressure from the central office and, in turn, from principals. The Director of Education made a videotape encouraging teacher involvement. Principals were directed by the Superintendent of Personnel indicated that certificates would be placed in the files of teachers completing the course. Additional incentives for teacher participation included offering the course at no cost at their own school, so they did not have to drive anywhere and could learn with their peers.

As elsewhere indicated (Professional Development and Assistance), this combination of administrative pressure, in-service support succeeded in getting teachers to try out the new hardware and software in the lab classroom. In her follow-up study the next year, however, Lee (1986b) found that the impetus to implement had subsided in some schools, though others were forging ahead. In talking with teachers, Lee found that most of them had no idea of the Board's direction for computers. There was apparently little ongoing pressure on teachers from the central administration regarding implementation, except the requirement that all new staff take the 16-hour inservice before using the lab. There was ongoing central support in the forms of consultative help on request (workshops, one on one, etc.), additional funds for equipment, written support materials, coordination of the computer lab schedules between schools. School level factors, rather than central direction and support, seemed to exercise the greatest influence on degree of implementation in these schools (Lee's findings may not be generalizable to the large number of other schools, about 56, involved in the effort). Lee's study raises the question of whether follow-up central office incentives and/or pressure might have stimulated the two low utilization schools towards greater utilization.

Central office support for the acquisition of GEMs is evident in recent field data sources (see Consensus/Conflict). The picture of policy direction and support for dissemination of the new software is less clear. In the up close view, it is not necessarily in the best interests of teachers and implementation to make the new software materials directly available as they come out. In the board studied by Lee (1986a), for example, a decision was taken to restrict access to the full spectrum of OESS distributed programs until teachers had the opportunity to get comfortable with the systems and a few software items introduced in a four to six week inservice training program. This was done to avoid overwhelming and overloading novice users during beginning implementation. As reported in interviews with field researchers from the Ontario Institute for Studies in Education, however, local choices about software distribution are not always based on principles of effective support for implementation, and do not always reflect a commitment to the intended educational uses of these learning materials. Reports of restricting access to materials that might upset school curriculum organization rigidly structured by grade level is one example. In other words, priority is given to not rocking the boat, as opposed to maximizing

the potential learning outcomes the technology has to offer. To summarize, from the board level perspective, immediate distribution of the new software is not necessarily seen as the best way to go. The motivations underlying local decisions to control access to software for use on GEMS, however, are not always consistent with the educational aims for NET envisioned by the ministry.

Much has been said about the importance of administrative latitude for risk-taking and experimentation by teachers using the technology, due to the uncertainty about effective usage and student outcomes. Early field data (e.g., Larter et al. 1983; Carmichale et al. 1985) indicate that administrators have given relatively free rein to variations in use. Comments from one of the OISE researchers interviewed, however, illustrate that the absence of clear expectations is very discomforting for some teachers.

Boards want them to just get comfortable with using the technologies. Expectations have been relaxed. But this causes an inner conflict for teachers and stress for teachers. They have no guidelines about what to do. They are not used to operating under no guidelines. Of course, there are some teachers who are exploring and enjoying the chance to take a risk.

The quote directs attention to two issues. One, that boards may be encouraging variation in use more as a palliative to gain teacher acceptance, than as a strategy to discover the most effective uses. Second, that initial latitude for variation and adaptation is less effective in the absence of clear policy direction and agreement on desired outcomes of implementation. Note that the desired outcome might be "clear models of effective practice in using microcomputers in the classroom", rather than some pre-specified configuration of uses.

5. Process for Implementation and Institutionalization

Successful implementation does not just happen. The people organizing and facilitating a change effort must have a vision of the change process that is conceptually sound, organizationally practical, and politically sensitive to the local and external context. Above all they have to be able to put together a clear organizational model and set of procedures for achieving implementation and

continuation of change. In a very real sense an effective process for implementation is one that explicitly takes into account the other nine factors examined in this section.

Good implementation requires good planning. Plans do not have to be in the form of elaborate documents, but they do need to focus on the right factors and have the approval of people in positions of authority to see that they are carried out.

During the initiation phase, planning should focus on creating an organizational structure and process for the change. This includes setting realistic timelines for implementation and deciding when to introduce it to different target groups throughout the system, as well as determining strategies for such things as acquiring and distributing materials, communicating role expectations, providing initial and follow-up training, consultative assistance, monitoring and problem solving. It also means establishing a priority for the project and coordinating it with other innovation projects in the local setting. Research suggests that widespread participation of implementors at this stage of the planning process is not essential, as long as the planners have a good sense of the factors influencing change and what can be done about them.

Effective planning during implementation involves a basic shift in focus from the organizational design for project implementation to the progress, problems and concerns that arise. This ensures that resources are directed where needed, and may lead to changes in the original game plan and support system. Orchestration and coordination are critical functions during implementation. Some person or persons in change facilitating roles must work actively at keeping things together and people in contact. In other words, setting up an organizational process is one thing. Making it run is another.

Good planning at this stage is dependent upon active input and participation of users and front-line managers and facilitators, since they are in the best position to identify the nature and location of problems, and may contribute effective solutions from the field. While a top-down approach can be used at the initiation stage, administrators must share control over the process with the users during implementation.

Planning for institutionalization is chiefly a responsibility of administrators. Significant changes may be short lived unless attention is given to ongoing budget requirements, replacement materials, training of new personnel, supervisory and support roles and the policies needed to carry on. It is worth noting that successfully implemented innovations often do not become "mandatory" until they reach the institutionalization stage, once their effectiveness and acceptability has been clearly proven.

While the discussion in this introductory section is somewhat general, there are indeed quite specific models and procedures for implementation planning, now being used in Ontario school boards (see Fullan, Anderson and Newton 1986). The significance of establishing a clear process for implementation can be best appreciated by observing that in the absence of such a process even very high initial enthusiasm on the part of teachers can be squandered. Similarly, early reluctance is often transformed to commitment when supportive procedures are used see Huberman and Miles 1984).

PROCESS FOR IMPLEMENTATION AND INSTITUTIONALIZATION.

Broad picture: Uncertainty exists about local organizational approaches to NET adoption and implementation. Systematic local planning for diffusion of the technology and implementation support is strongly encouraged. Board proposals for GEMS purchases and use do not reflect actual rate of acquisition.

Up close: Early focus of local planning has been on hardware/software acquisition and distribution and on in-service and consultative support for interested teachers. Equal access to the technology is the dominant organizational concern, not implementation. Heavy reliance on spontaneous development of in-school expertise for implementation assistance is typical at the local level. Early support for pioneers is now shifting to concern for large-scale implementation involving all teachers. Local attention to resource and training needs for institutionalization of NET use in schools is just beginning. Research is needed on current organizational approaches to system-wide implementation of microcomputers.

Process for Implementation and Institutionalization: Broad Picture

We did not specifically ask our interviewees what organizational approaches they thought school boards were taking in regards to NET implementation generally or to GEMS and OESS products specifically. The pervading sense, however, is one of uncertainty. There is uncertainty at the ministry level as to what an effective school board level implementation model and process would look like, and the extent to which boards are, in fact, developing systematic approaches to introducing and supporting the use of microcomputers in schools.

There is a clear perception at the ministry that long-range planning for utilization of computers in education is essential at the local level. A 1983 Policy/Program Memorandum strongly encouraged school board-level planning and identified a range of issues which those plans should address--e.g., educational objectives; curriculum (content, software selection, evaluation, implementation monitoring, integration of OESS materials, etc.); computer equipment (current/anticipated uses and distribution, future needs, coordination with in-service, integration of GEMS, servicing); administrative support services; implementation strategies and in-service plans; resource requirements and source of external assistance. A 1987 Policy/Program Memorandum (No. 91) states less equivocally that "school boards should design and implement system-wide and/or school-based plans that will help teachers and their students to exploit this technology for educational purposes in all appropriate areas of the curriculum". An Advisory Bulletin distributed with that Memorandum suggests the following basic components of an implementation support system should be included: appointment of curriculum and technical computer support personnel, allocation of teacher planning time, inservice training for teachers in curriculum-based uses of the technology, release time for inservice, resource sharing among boards, dissemination of research findings about use of the technology, communication with parents about integration of the technology into the learning process.

The policy recommendations cited above suggest a framework for local planning and for setting up an organizational structure for NET adoption and implementation, though boards are not actually required to submit such plans. Boards have been required, however, to submit specific plans justifying their

requests for Recognized Extraordinary Expenditure (REE) grants each spring to purchase additional GEMS. Although we did not review these documents, their practicality for implementation seems dubious, since the number of GEMS requested has always outstripped the grant monies the ministry has been able to deliver.

In conclusion, while there have been initiatives from the ministry designed to encourage systematic approaches to NET implementation at the local level, there is not really a well developed picture at the ministry level of how the boards are going about it.

Process for Implementation and Institutionalization: Up Close

The field data reviewed for this report do not really give us a good handle on overall local organizational processes for board-wide NET implementation. Some studies focus on projects involving individual schools or teachers, rather than implementation across the system (Pilot School Projects, 1983; Carmichael et al. 1985). The most complete descriptions of board-level approaches date back to the early 1980s, when 8-bit microcomputers were just beginning to come into the systems in a big way (Provincial Review Report, vol. 5, No. 1. 1981-82; Larter et al. 1983).

On the whole, these data indicate that the main focus of planning initially are the acquisition and distribution of hardware, deciding on the general approach to use in schools (e.g., classroom based, permanent or rotating labs); software development, evaluation and distribution; providing access to introductory computer courses for interested teachers; and creating board-level computer resource positions. The predominant concern is making sure that schools, teachers and students have equal access to available equipment and materials. Boards may offer local teacher training opportunities or facilitate participation in external professional development activities, but the common strategy is to let individual teachers or schools decide on their own approach to professional development. Assistance with microcomputer implementation is being handled much like subject areas of the curriculum, by appointing central resource personnel to assist with professional development and provide

consultation on request. Some are involved in curriculum and software development. It seems safe to say that boards have relied a great deal on in-school expertise for implementation assistance, i.e., the resident experts. This appears less as a feature of organizational design, however, than as an adaptation to grass-roots initiative in the schools.

Until recently, most boards have probably not had enough hardware in the schools to seriously worry about implementation support for teachers other than the core group of enthusiasts who voluntarily get involved. System-wide in-service programs such as that described by Lee (1986a,b, see Professional Development and Assistance) suggest a growing willingness to tackle the broad-scale problem of NET implementation.

Data on what school boards are doing to support the institutionalization of NET utilization in the schools is sketchy. It is evident that they are acquiring more and more hardware. Findings from the early studies of Larter et al. (1983) and Carmichael et al. (1985), however, indicate that in some situations hardware acquisition has proceeded without anticipating the ongoing costs for maintenance and replacement and peripheral equipment. The widespread creation of computer resource positions at the board and school levels is an indication of local steps towards institutionalization, but most of these are probably term appointments whose longevity is by no means assured. On the in-service side, evidence of systematic programs for introducing the technology of (GEMS) to new staff on an ongoing basis is provided in Lee's (1986a,b) reports, but we cannot estimate how common that practice is or will become.

Research is needed to find out how boards are organizing support for NET implementation at the system level, particularly as it pertains to the introduction and classroom use of GEMS and OESS materials. Given the recent development of systematic Curriculum Development, Review and Implementation models in many boards (Fullan, Anderson and Newton 1986), it would be useful to see whether and how these organizational approaches to curriculum change apply to the introduction of the new information technologies.

6. Professional Development and Assistance

Staff development activities are important both for the dissemination and the implementation of educational innovations. Introductory workshops may suffice for innovations requiring only minor alterations in practice, but those requiring substantial changes in practice are unlikely to succeed without follow up in-service and consultative assistance during implementation.

The characteristics of effective professional development programs are fairly well known. The greatest effects are achieved when explanation of new practices is combined with demonstrations, opportunity to practice in non-threatening contexts, and individual feedback (i.e., "coaching") back in the classroom. Staff development activities can come in a variety of types -- event-specific workshops, meetings, conferences; ongoing consultants, support group meetings, user manuals -- and from a variety of sources -- external consultants, board consultants, knowledgeable administrators and fellow teachers. Regardless of their identity the providers must be credible to teachers implementing the change, and the activities should focus on assisting with implementation of specific innovations. Staff development during implementation should be oriented increasingly towards implementor level-of-use of the innovation and/or known implementation problems, as opposed to general characteristics of the innovation.

Studies of successful implementation efforts have repeatedly documented the importance of ongoing interaction among innovation users during implementation. Such encounters can provide an opportunity for sharing, joint problem solving, identifying needs for in-process help and innovation adaptation, and monitoring the progress of change.

Release time for staff development and individual planning is also a valuable form of assistance, particularly during the early stages of implementation when teachers are still struggling with the mechanics of organizing and learning how to carry out new practices.

A critical and often overlooked component of staff development is the need to institutionalize provisions for ongoing socialization and training of new staff members with the use of the innovation.

The impact of quality professional development and assistance during implementation is not just progressive mastery of new practices. The ongoing attention accorded to an innovation helps communicate the seriousness of the effort and can stimulate greater commitment on the part of implementors.

Humberman and Miles (1984:273) in their detailed examination of 12 case studies summarize the point best:

"Large-scale, change-bearing innovations lived or died by the amount and quality of assistance that their users received once the change process was underway...The forms of assistance were various. The high assistance sites set up external conferences, in-service training sessions, visits, committee structures and team meetings. They also furnished a lot of ongoing assistance in the form of materials, peer consultation, access to external consultants, and rapid access to central office personnel... Although strong assistance did not usually succeed in smoothing the way to early implementation, especially for the more demanding innovations, it paid handsome dividends later on by substantially increasing the levels of commitment and practice mastery".

Such a serious and powerful approach to ongoing professional development and assistance is especially needed in the case of NET given our analysis of the characteristics of the innovation. Of all the factors influencing implementation, professional development (of the type we are describing) is most critical. Hence, we consider the role of this factor in some detail.

PROFESSIONAL DEVELOPMENT AND ASSISTANCE

Broad picture: Non-users needs focus on initial acceptance and skills to operate equipment. User needs focus on methods for using in the classroom. Professional development should include demonstrations, hands-on experience and coaching, practice/planning time, ideas for classroom use, ongoing contact with other users, and access to consultative help for mechanical and teaching concerns. Traditional professional development services are not oriented to GEMS and OESS materials. Consultative help is mainly from local board and school resource people. Ministry support for professional development and assistance will be indirect and based on multiplier strategy. Proposed initiatives are oriented more towards front end than ongoing support for implementation. Uncertainty exists about good inservice models.

Up close: A wide variety of external professional development services are used. NET use spreads more rapidly when school-based groups of teachers take part in organized in-service activities within the board. Help is required initially and during implementation, and must be combined with attention to other implementation factors (e.g., role of principals). Teacher needs for demonstrations, hands-on experience, personal assistance, practice time, credible trainers and incentives (e.g., release time, tuition, recognition) are confirmed. Needs for help with instructional uses of the technology in the classroom are still critical. Board and school-level computer resource positions with widely varying responsibilities are evolving from local initiatives. GEMS/OESS materials are unfamiliar to most local sources of advice and assistance (consultants, in-school experts, parents, user groups, students).

Professional Development and Assistance: Broad Picture

Ministry officials distinguish different target groups of NET users whose professional development needs vary depending on their positions and prior experience with microcomputers. Traditional user groups, such as computer studies and math teachers, tend to be interested in computer languages, programming and how computers work, whereas the majority of teachers just want to know how to use the technology as a resource for learning. For teachers who have little or no experience with microcomputers and software, the major

hurdles initially are to interest them in the benefits of using the technology in the classroom and to get them comfortable with the mechanics of using the equipment. For the ministry, the technological goal is to make the hardware and software so easy-to-use that teachers and students will not have to know much about how they work. For the time being, teachers still need some mechanical know-how to deal with minor technical procedures and problems.

For teachers who have overcome the initial attitudinal and mechanical barriers, all ministry sources agree that the main focus of professional development should be to help them learn how to integrate the use of computers and software into the regular curriculum and classroom activity. Major learning needs for classroom use include:

- what specific software can do
- how specific software works
- how to integrate the software into the curriculum
- how to use software as an integral part of classroom activity
- classroom organization issues e.g., facilities, scheduling, grouping student interaction)
- pupil evaluation methods

Over time, teachers will need to learn to use different modes of software, i.e., utilities (wordprocessing, graphics, etc.), generative/creative modes, direction instruction, drill and practice, tutorial, simulations, games, and record keeping. The overall emphasis, however, would be to help teachers learn to exploit the creative learning potential of available software.

So far the ministry has relied mainly on traditional sources of professional development for teacher training to support NET implementation. The faculties of education are a major source. A computers in education course is now required in pre-service programs. Other computer related courses are offered, as well. On the in-service side, the faculties run a three-part Computers in the Classroom program for the ministry, which leads to a specialist certificate in computers in education. According to one interviewee, this has been one of the most heavily booked additional qualifications programs in recent years.

TVOntario runs a popular introductory course by television called "Bits and Bytes". One of the ministry officials interviewed reported that about 20,000 teachers had registered for that course since it was first offered. Of course, Boards of Education organize and offer in-service workshops and programs on their own and in collaboration with the Teachers' Federations. New associations of educators committed to computers in education, such as ECOO (Educational Computing Organization of Ontario), hold annual conferences with workshops.

A characteristic of all these sources of professional development is that they have not been specifically geared towards teacher training on the use of GEMS and OESS materials. Thus, while they may be helpful in getting teachers interested and familiar with use of the technologies, and furthering their general computer competence, their direct relevance to implementation of the ministry's NET priorities is uncertain. It is unclear the extent to which this might be changing since GEMS and OESS materials came on to the market. Some ministry officials believe that much of the training provided in the past has not gone far enough because it has been directed more to computer literacy (familiarity with computers) and programming.

Specific introductory training in the use of ICONs is available from the hardware distributor, UNISYS. Two day courses are offered on a regular basis throughout the year. Details about the location, organization and content of these courses were unavailable in our data, though company brochures state that the focus is on how to use the technology in the classroom.

The current thrust of ministry support for NET implementation will focus mainly on the use of GEMS and OESS distributed materials, and more recently (February 1987) on the funding of six "lighthouse implementation projects" designed to support the establishment of exemplary implementation, and the identification of effective implementation strategies within these sites, which might be disseminated to other boards across the province. Ministry officials have reasonably explicit ideas about the kinds of things a staff development design, particularly for new users, ought to take into account.

- opportunities to actually see teachers and students using the technologies in a classroom setting (whether by visiting demo classes, seeing videos, or letting consultants do demos with their own students)
- opportunities to actually see how motivated students are to get on and work on the computers
- opportunities and time to practice with the machines until comfortable with mechanical procedures (hand-holding assistance desirable at this point)
- opportunities and time to sit down at computer and work with new software to learn what it's about, how it works, and to get ideas about how to use
- concrete ideas about how to use with students in the classroom (whether provided on the program documentation, by demo, by consultants, by support print materials)
- time to plan lessons, unit, activities, etc.
- person to person contact with other users as an important emotional support, problem solving support and source of ideas for use.
- teacher education in the use of microcomputers.

A popular ministry scenario for new users is to give them first hand exposure with one or two high quality OESS programs while developing their initial commitment, comfort and user skills. Some officials believe that mastery of the basic operational procedures should be attainable with one to two hours demonstration, hands-on practice and coaching. Learning the potential uses of the software, on the other hand, is characterized as a lifelong affair. While the need for training on the hardware should decrease as the machines become more easy-to-use, the need for training in software use is likely to be ongoing as

the software becomes more sophisticated. Some officials seem to think that the software documentation should be enough to get teachers going with the programs. Others say most teachers still need demonstrations and a lot of ideas about software use in the curriculum and classroom.

It has not been ministry policy to provide direct professional development for teachers, but rather to facilitate opportunities for professional development through other agencies--faculties of education, teacher federations, boards of education, technology suppliers, etc. While maintaining the "arms-length" policy, there is consensus within the ministry that more proactive support for teacher training is necessary for the success of NET implementation.

Current in-service initiatives and proposals emphasize the perceived need for "hands-on direct and personal experience." TVOntario has been funded to develop an in-service workshop model for use of OESS materials. The ministry also funded the production of a videotape demonstrating the integrated use of several OESS programs in different classroom settings. The tape is available to regional and local computer resource personnel for workshops. Other proposals under consideration include seconding region-level consultants to organize implementation activities for boards within each region; equipping and staffing (using secondees regional user support centers, where teachers can observe and participate in professional development activities; designating lighthouse schools, where teachers can visit, observe and work with regular staff in exemplary settings on a short-term basis; setting up centres to help teachers acquire software development expertise; and providing transfer grants to help local board defray the costs of implementation activities (e.g., speaker fees, travel, supply teachers, materials).

On the whole, it is evident that the kinds of projects and proposals envisioned so far by ministry officials are primarily oriented towards awareness, demonstration and practice at the front-end of implementation for innovation users. Strategies for systematic follow-up support for implementation assistance, at the school and classroom level, are not built into most of these conceptualizations, although the six boards funded through the "lighthouse implementation project" will be expected to incorporate assistance strategies into their project designs.

These proposals notwithstanding, the general feeling at the ministry is that the characteristics of effective in-service approaches to NET implementation are not yet well-in-hand. Starting with the lighthouse projects, there are plans to fund in-service projects in some school boards "to determine what kind of teacher training will be most effective." In keeping with its traditional facilitating role in professional development, ministry officials do not plan to get involved in large scale funding and direct in-service training. The basic intent is to build up cadres of local/regional people effective in training and to create a multiplier or "snowball" effect. For example, access to GEMS have been made available to the faculties of education with the intent of developing their expertise, so they can assist in local school system in-service programs.

At the ministry level, the major constraints to mounting an in-service oriented implementation initiative are lack of knowledge about effective in-service models, funding and lack of staff.

There is an education officer in each Regional Office responsible for computers in education. To date these officials have mainly functioned in an information liaison capacity and managed the allocation of ministry grants for local hardware purchases. They have not played a major proactive consultancy role in organizing/providing assistance to school boards in the Regions. Most consultative support has been local. Ministry officials cite the spontaneous evolution of "resident computer experts" in most schools and of computer consultants/coordinators in many Boards. The expertise of local resource personnel, however, is not necessarily based on familiarity with GEMS and OESS materials which are the focus of the ministry's implementation initiative. Furthermore, local expertise in NET needs to be informed by expertise in designing and carrying out effective systems for professional development and assistance.

Support materials constitute another source of consultative assistance. In this regard, the ministry now requires suggestions about the use of microcomputers and software to be incorporated into all new/revised provincial curriculum guidelines and resource documents. Local-level development of resource materials to give teachers practical suggestions for using GEMS and OESS

materials is said to be taking place in some jurisdictions, and is regarded as an important supplement to the ministry's own efforts. A ministry funded project to develop support materials is scheduled for the Summer 1987.

As noted elsewhere in this section (see Quality/Practicality), time is a critical resource need for teachers implementing the technology. Ministry officials acknowledge user needs for in-service and planning time both initially and on an ongoing basis, as teachers attempt to implement additional curriculum software and hardware innovations into their programs. Our interviewees expressed the opinion that organizational arrangements should be made locally to accommodate the time requirements during the regular school day. An Advisory Bulletin appended to a 1987 Policy/program Memorandum (No. 91) explicitly encourages school boards to support "the allocation of time for teachers to develop comprehensive implementation strategies" and "release time for inservice training."

Efforts to improve teacher access to consultative assistance are being considered on several fronts. The first is to set up the previously mentioned Regional Consultancy positions, seconding expert teachers from the school systems for one to two year terms in each Region. A second proposal is to institutionalize the resident expert role in each school. These local "site administrators" would be available to help other teachers with mechanical problems and with questions about possible instructional uses. Like other kinds of resource or lead teachers, they would still carry normal teaching responsibilities. One of the officials interviewed noted that people identified as resource personnel will need expertise in training/consulting skills, as well as in the mechanics and pedagogical uses of the technology. The possibility of facilitating exchanges and sharing of locally developed resource materials between boards is also mentioned.

The third thrust of ministry proposals to increase teacher access to consultative assistance is to facilitate user interaction through microcomputer-based communications networks. While the potential for such a system is technologically feasible, and a basic infrastructure already exists through the Educational Computer Network of Ontario (ECNO), there are unknown cost

considerations. Of course, using such a system, even if it were available, would constitute a major additional innovation for most teachers.

By way of conclusion, note that most of the above initiatives are in the very early stages or are plans for the future.

Professional Development and Assistance: Up Close

Drawing conclusions about the "up-close" character and impact of NET related staff development and assistance is difficult, due to the lack of detail on this component of implementation support in the field data consulted. What we can do is summarize what kinds of support activities have been going on, identify some major variations in approach, and formulate some impressions of their effectiveness in terms of the diffusion of the technology to new users and the appropriateness of assistance provided. As in the preceding section, we begin with in-service and then move to consultation and other forms of help. The discussion of local in-service activity related to NET implementation is organized under the following topics: sources of training, scope of participation, timing and quantity, focus, organizational strategy and supportive arrangements (i.e., design).

Sources Of Training

Early field studies (Pilot School Projects 1983; Larter et al. 1983; Carmichale et al. 1985) indicate a wide variety of external and within-board sources of initial professional development. External sources include the three-part specialists course, the TVOntario course, University and Community College courses, computer user group conferences, training through other public/private organizations, self-instruction materials, family and friends. Sources internal to the boards include invitational courses and workshops, school-specific workshops, continuing education courses and other teachers in the building. Parent volunteers and even pupils are mentioned as sources of teacher training in some schools.

Data from these studies show that some schools and boards rely mainly on external professional development sources. Others organize their own in-service programs, in addition to what teachers can get on the outside. We cannot judge the relative quality of external and internal professional development sources. Findings from the Pilot School Projects and Logo-use studies, however, do suggest that NET use spreads more rapidly at the school-level when teachers have access to and take part in a variety of in-house in-service activities.

Assuming that the number of computer resource personnel in school boards has increased since these early studies, it seems reasonable to suppose that there has been a corresponding increase in the amount of in-house professional development activity related to NET use, especially for the new GEMS and OESS products. While the availability of assistance from external agencies and community volunteers has probably not decreased, the lack of widespread familiarity with GEMS and OESS materials probably limits the number of external sources with appropriate expertise.

Scope of Participation

School-level diffusion of microcomputer use appears to be linked to the scope of in-service participation, as well. The Pilot School Projects and Carmichale et al. studies indicate lower percentages of use and slower spread to non-users in schools where only a few teachers take part in in-service opportunities. In a study of microcomputer implementation in several school districts in the U.S., Yin et al. (1984) found that the rate of adoption (the number of machines acquired over several years) was correlated to the presence or absence of group training activities (in addition to individual assistance). Lee's investigation of microcomputer use following intensive school-wide inservice programs, lends additional support to the view that training teachers in school specific groups is an effective way to stimulate widespread beginning implementation in a board (Lee 1986a,b). The point is that a strategy based on intensive training of key teachers may be less effective if it does not include organized in-service provisions for the other teachers (i.e., if the key teachers are left to spread the gospel one-by-one).

Timing and Quantity of In-Service

Not much can be said at this point about the nature and consequences of variation in the timing and quantity of in-service provisions supporting NET implementation at the school level. Three of the five schools in the Pilot School Projects benefitted from fairly heavy doses of front-end training for all staff, and ongoing access to a variety of internal and external staff development sources. One relied on key teacher training initially, but coupled that with ongoing access to in-service for pilot project and other interested teachers. The school which experienced the least success, in terms of number of users, teacher acceptance and comfort with use of the technology, only got an "hour or two of demonstration with some hands-on activity" at the start. Some of the teachers supplemented this with external courses on their own accord. In their conclusions, the authors of that study recommended "that as much in-service as possible be provided to teachers by both boards and individual schools" and through the various external agencies.

In our view the issue is less a question of quantity than of balance, i.e., the need for assistance (both in-service and consultative) during as well as at the beginning of implementation. Twelve of the 13 teachers participating in Carmichael et al.'s Logo-use study, for example, already had previous training and experience with computers (half had already used Logo), but received no specialized training or help during the project (except a Logo Users Manual). Yet the teachers all expressed strong needs for additional in-service and consultative support at the curricular and technical levels. As one put it, "presenting a teacher with the program and the manual and nothing else was like a nightmare."

Lee's (1986a) research on microcomputer use following an introductory in-service for elementary teachers learning to use the DRAW, EDIT and LOGO programs on ICONS, provides another example of the need to structure ongoing support for implementation. The initial in-service combined weekly after school explanation, demonstration and practice sessions (4 hours per week, 16 hours total) with immediate application, adaption and coaching assistance in the computer lab over a four to six week period in each school. The classes were taught by a board consultant. Computer resource teachers remained on

site to help teachers on a daily basis. A training manual was provided as well. Although 95% of teachers at each site participated in the in-service and tried out the innovation with students in the lab, the level of mastery obtained by the end of the initial in-service was modest (see Complexity: Up Close). In her small scale follow-up study in four schools, Lee (1986b) found that the scope and frequency of teacher use, and by extension teacher mastery of NET use, was much greater in some schools than others by the following year. Inservice support from the central office as split between continuing the introductory inservice for teachers who had not yet been trained, and offering follow-up workshops and consultative help from Computer Consultants assigned to each family of schools. Interestingly, principals in all four of the schools studied by Lee permitted the consultant to offer and provide additional assistance, either after-school workshops or one-on-one consultation during school time. More teachers in the high use schools took advantage of the extra outside help than in the low use schools, and there was more evidence of ongoing peer assistance in the high use buildings. Lee's findings draw our attention to two strategic points. First is that the quantity and sophistication of front-end training and provision for ongoing external assistance can be a valuable stimulus and resource for implementation. Second is that the negative influence of other organizational factors in some schools (e.g., low staff consensus on priority and need for change, unclear direction to change from principal, absence of sustained peer interaction focused on improved implementation) can offset the benefits accruing from well-organized external professional assistance. In short, good professional development helps, but will not do the job on its own.

In Service Focus

What can be said about the focus of in-service provided or obtained locally for NET implementation? For obvious reasons, not much is known yet about staff development specifically geared to use of GEMS and OESS materials. Lee's study, some of the OESS field test reports and scattered comments in our interviews are about all we have to go on. Thus, our picture of local in-service activity and needs relates mainly to the use of other products.

The impression gathered from the early studies of implementation in Ontario schools is that most of the training has centered on talk about computers and

their potential uses, learning to operate the equipment, learning to program and learning to use specific items of software (e.g., Logo, word processing packages). Teachers' expressions of additional needs fall into two broad areas. One concerns software selection and development. The other focusses on the need for more help with curriculum integration and methodologies for using the technology in the classroom. To put it another way, most of the in-service has not been tied into specific strategies for classroom use. It has not focussed on instructional use. Respondents to the 1986 TVOntario surveys of microcomputer use among elementary and secondary teachers suggests that this gap in in-service focus is still a problem. While most users rated their training experiences as fairly to very effective, the two common "shortcomings" identified were "not enough practical examples" and "not enough time on subject area" (Kwong 1986).

Larter et al. (1983) documented considerable "confusion and controversy" over teacher training content and methods during the early days of microcomputer implementation in Toronto elementary schools. People were questioning the teachers' need for programming expertise, technical know-how to handle repairs and peripheral equipment (e.g., printers, disk drives), software evaluation and development skills. Disagreement on teacher training needs was partly attributable to a lack of consensus on NET objectives for students and the absence of clear policy directions at the board and ministry levels. We are not in a position to say whether subsequent policy initiatives from the ministry and local authorities, and increased experience with use of the NETs, have brought teacher training needs in this and other boards into clearer focus. We can say that until local consensus is reached on what students and teachers are expected to do with the technology, in-service activities are likely to be poorly coordinated with each other (thus reducing their collective impact), and weakly linked to classroom use (thus reducing their appropriateness and power from the user standpoint).

It is tempting to speculate on the consequence of the ministry's software development program. In theory, teachers using OESS materials would have less need for software evaluation and development skills than teacher relying on commercially developed software, though field data available did not provide insight into that question. The data do suggest, however, that teachers' needs

for help in understanding how the software works and what it can do, how to relate it to the curriculum and how to use it in the classroom, have not been eliminated by the production of "easy-to-use" materials explicitly oriented to provincial curriculum goals. Pike (1985), Gillis (1985; 1986) and Lee (1986a,b) all document teachers' difficulties understanding what to do with software developed for GEMS use and how they related to the curriculum (see Clarity/Complexity: Up Close). An OISE researcher studying the implementation of GEMS and OESS products in the field had this to say:

Teachers need a lot of ideas about how to use the programs. They have the powerful tools. They have to know its potential for use. They have to have ideas. There are no lessons about being creative with it.

As pointed out earlier, internal documentation of software utilization ideas on the programs has not proven an effective method of teaching new users what to do (see Quality/Practicality: Up Close).

Lee's (1986a) analysis of the effects of an intensive introductory in-service program suggests that accomplishment of local in-service goals for use of GEMS and OESS materials is more likely to happen incrementally than all at once. For that project, the in-service training manual specified several long-term objectives -- making teachers comfortable with use of the computer in the classroom, developing a critical awareness of potential uses, developing skills for curriculum integration and software evaluation, and developing skills in using three types of programs (DRAW EDIT LOGO). Based on teacher questionnaires and classroom observation in five schools (out of 60), Lee concluded that the initial inservice was successful in getting teachers to try out the hardware and software with students. Teacher comfort, awareness of uses, skills in curriculum integration and software evaluation, and skills in using the chosen programs were in beginning stages of development for most. This experience focuses our attention on the inescapable developmental nature of the teachers' mastery of NET use.

Local In-Service Design Strategies

This brings us to the critical question of local in-service design. We have already noted several design issues -- the importance of ongoing as well as introductory in-service activities, of combining in-house activities with external source of professional development, of structuring some group training for users within the target schools, and of matching in-service expectations and activities to teachers' levels-of-use. Field data on teacher training for microcomputer use in the classroom point to a number of other local design issues, including participation requirements, scheduling (after school vs. during school), the need for hands-on experience, access to immediate personal assistance, practice time, credible trainers and incentives (e.g., free training, tuition subsidies, certificates).

We cannot really comment on the merits and drawbacks of mandatory or voluntary in-service. Personal communications from two of our field sources, however, indicate that because of the emphasis being placed on NET use by system officials (and parents), teachers often think that training is obligatory when offered at the school level. This perception grows when in-service is accompanied by public pronouncements of support from officials, and when it is coupled with access to equipment, materials, release time, consultants, etc. In any case, expectations to use NET are so high that most teachers probably end up wanting or thinking they should use NET. We would venture to say that problems of implementation and associated needs for professional development apply both to enthusiastic and reluctant users. Motivation is no substitute for technical competence.

The question of scheduling professional development activities is the same as for other major classroom innovations. Teachers would like release time for professional development during the school day, but most of it goes on after school. and the availability of funds at the board and school levels for supply teachers is always contentious.

All sources on local implementation experiences indicate that beginning users should not be expected to implement the NETs on their own. They need access to demonstrations and at-the-elbow assistance, both in learning to use the

technology itself, and as an integral part of classroom activity. Findings such as those from the 1986 TVOntario surveys suggest that videotapes and print documentation may not satisfy teachers needs for personal contact with credible trainers/coaches.

**Useful Modes of Presenting Utilization Ideas of
Integrating Educational Software Programs into
the Curriculum (Kwong 1986)**

	Secondary Teachers (N=275)	Elementary Teachers (N = 709)
Print documentation	2.1%	4.9%
Workshop	10.6%	11.5%
Workshop w/print documentation	36.2%	41.5%
Videotape	0.0%	0.0%
Videotape with print documentation	6.4%	3.5%
Workshop with videotape	0.0%	2.4%
Workshop with videotape and print documentation	42.6%	35.7%

Caution is warranted in interpreting these findings since they may be more indicative of the kinds of in-service activities typically provided than of their relative merits. The use of videotape demonstrations, however, is a staff development "innovation", the effects of which are uncertain (and worth studying).

Another recurrent theme in field data on NET implementation is the need for hands-on experience (for both beginning and experienced users) and practice time on the machines with the software. The need for user practice time to master the mechanics and explore the software functions clearly distinguishes this innovation from most curriculum changes. A typical local strategy has been to combine in-service activities with provisions for teachers to take the hardware

and software home overnight or on weekends. As previously noted, however, the size of the GEMS makes this strategy less practical than for traditional microcomputers (see Quality/Practicality: Up Close).

Consultative Assistance

In-service and practice time are two kinds of help. Access to consultative assistance is another. Local implementation data confirm the need of teachers for ongoing access to knowledgeable and credible computer resource personnel, both for technical questions/problems and for ideas about classroom use. While we know there are increasing numbers of board computer coordinators and consultants, data on the actual activities and impact of these people on NET implementation is sorely lacking. Lee's (1986a,b) accounts of the inservice support roles of a computer coordinator, computer consultants, and computer resource teachers was our only example. There is more information about the evolution and roles of "resident experts" in individual schools.

Larter et al. (1983) documented the spontaneous evolution of school level computer resource personnel in their study of the introduction of microcomputers in Toronto elementary schools. These were usually enthusiastic teachers who had acquired their expertise outside the local school system. Their tasks and roles varied from school to school -- technician, teacher trainer, software writer, coordinator of equipment and materials. Most performed the role unofficially in addition to their regular teaching duties. The researchers report that these individuals were highly committed to the innovation, but under considerable stress due to the overload of requests for help, the fact that they were not given official time and, in some settings, confusion in lines of authority in regards to decision-making about microcomputer use in the school. In the Logo-use study, project teachers were often the first users in the school. Carmichael et al. (1985) report that many became involved not just in training their colleagues, but also in providing computer instruction for students other than their own.

According to the 1986 TVOntario surveys, the presence of in-school computer resource personnel is now quite widespread. Ninety percent of the elementary

and 79% of the secondary teachers answering the survey said there was an in-school resource person in their building. The proportion of those officially designated by the principal or central office equalled those acting in an unofficial capacity. What official status means in terms of role definition, time, extra-pay, etc. is not reported. The major services indicated at both the elementary and secondary levels (by 50% or more respondents) include assistance in setting up equipment, training in using microcomputers and providing software information. Assistance with integrating software into the curriculum was only checked by a third of the respondents. Clearly, most of these school-level computer resource teachers gained their expertise with machines and software other than GEMS and OESS materials. We have no data on their reaction to or involvement in the adoption and implementation of the ministry priorities for NET use in the schools.

Three additional sources of advice and assistance in the classroom are mentioned in up-close accounts of early NET implementation -- parent volunteers, student experts, and local user support groups. Whether recourse to parent and student expertise developed through use of conventional microcomputers and software is appropriate in the implementation context of GEMS and OESS materials is an open question. While local user groups represent an important source of user-to-user help, the field data suggest that some of these groups have developed around the use of particular products (e.g., Commodore PET users). Information is unavailable at present to comment on the prevalence and activities of local user groups, the response of existing groups to GEMS and OESS materials, or the evolution of new groups oriented to their use.

Summary

We have gone on at some length about professional development in order to emphasize (1) its paramount importance, and (2) the great care and sophistication that will be required in formulating, coordinating and carrying out effective professional development, i.e., professional development that will be up to the task. Carmichael et al (1985:V) found that "teachers need strong technical, educational, emotional and social support in coping with changes demanded by the creative use of computers". Teachers' sense of competence

and mastery over the machine and software uses is the issue. Professional development must be characterized by access to high quality software, ongoingness, curriculum and instruction embeddedness, a variety of learning partners (e.g., coordinators, other teachers), a variety of learning formats (e.g., visits, workshops, meetings, group, one-to-one), opportunity for practice-practice-practice and feedback, and data on the impact of NET on students.

7. Implementation Monitoring and Problem Solving

The success of implementation is highly dependent on the creation of effective ways of getting information about implementation progress and problems from users in the classrooms to appropriate building and central administrators and assisters. While formal technologies for "evaluating implementation" are available, monitoring does not have to be conducted like research. The crux of the matter is to get the right people talking together about implementation issues on a regular basis. Furthermore, data on student learning and attitudes is needed for a number of reasons including feedback on progress, and at some point information to decision-makers.

Getting information about implementation progress needs to be channeled into provisions for additional in-service and assistance, materials support, and possible modifications in plans, organizational arrangements and the innovation itself --i.e., problem solving.

The linkage of implementation monitoring to official performance appraisals is touchy. Available evidence suggests that teachers do not necessarily oppose this approach so long as they know it is coming, and as long as the focus is on helping them do it better, rather than evaluating them negatively if they only achieve partial success. It is another way of communicating the seriousness of administrators intent, but has to be tied into the overall support system if it is going to work.

IMPLEMENTATION MONITORING AND PROBLEM SOLVING

Broad picture: Provincial monitoring of implementation progress and concerns will take place through Regional committees of local officials and resource personnel, and through contract research in pilot and natural implementation settings. Research findings will be fed back to users, developers and policy makers, resulting in ongoing modification of the innovations and their uses. NET

developer/distributor hotlines provide for direct communication with users about technical bugs. The need for local implementation monitoring is hindered by lack of knowledge and consensus on how the technology can be used to best advantage, and how to evaluate its use and impact in the classroom.

Up close: Little information on how school systems are monitoring and using data on NET implementation is available. Local monitoring by central office and principals is made difficult by the lack of standards for effective use. Anecdotal craft knowledge about NET use is evolving from unstructured communication among users and local change agents.

Implementation Monitoring and Problem Solving: Broad Picture

Ministry sources emphasize the need for careful monitoring of ongoing developments in the NET field and of local implementation in the school system. The need arises from rapid changes in the technologies and continuing uncertainty about alternative products and uses. Present proposals call for a formal overall review of ministry policies, plans and programs for NET utilization every three years. Here we describe the perspective and approach to monitoring local implementation reflected in our interviews and ministry documents.

Ministry efforts to date have concentrated mainly on establishing policy directions and on supporting the initial development and distribution of GEMS and OESS materials. Apart from a few studies, such as those cited in this report, there has not been an attempt to monitor and respond to NET implementation in the schools until now.

There are two basic directions to the ministry's emerging approach to monitoring local implementation progress, problems and needs. One is through mechanisms for ongoing communication with people in the field. These include the Regional Education Councils (Directors of Education), Regional Curriculum Councils (Curriculum Superintendents) and newly established Regional Computers in Education Coordinating Committees. The latter involve Regional Education Officers responsible for NET concerns and Computer Consultants or representatives from boards in each Region. As part of its effort to ensure the curriculum relevance of new software for use on GEMS, the ministry software development program has a procedure whereby local school personnel can submit forms specifying their software needs on an ongoing basis. This information is considered when funding new software development contracts. Keying software to locally perceived needs should increase its potential acceptance by implementing teachers. Most of the ministry officials interviewed felt their present knowledge about local implementation progress and needs was biased by the fact that most of their field contacts are with committed users, rather than with the majority population of reluctant or non-users. That is unlikely to change through the communications structures proposed.

Research constitutes the second major thrust of ministry monitoring of NET implementation. There are two sides to the research undertaken or planned. On the one hand, the ministry plans to do ongoing pilot studies of the educational uses and effects of new technological devices and types of software before offering advice or recommending their use to school system personnel across the province. This is in addition to the procedures already established for piloting and evaluating software for use on GEMS. From an implementation perspective, this focus of research activity is likely to help reduce initial technical uncertainty about innovation effects/uses and improve the initial quality and fit of the innovations during the initiation phase of planned change. The other side of the research-based monitoring strategy focuses on the generalized use of the technologies across the province during the implementation phase of change.

The rate and pattern of hardware acquisition is also being monitored by requiring school boards and schools to include data on numbers and types of microcomputer systems in their annual September statistical reports. Of

course, data on the presence of microcomputers in schools only reflects on their availability, not on their use.

One research strategy mentioned earlier is to fund locally designed pilot projects to demonstrate and document classroom uses, curriculum relevance and student achievement, and implementation strategies associated with GEM use and software delivered through OESS. Information about these local pilot projects is to be assembled and disseminated to other boards through the ministry. This initiative, known as the "lighthouse implementation project", was announced in February 1987 and will fund six boards up to \$170,000 each (\$100,000 for GEMS \$70,000 for implementation support).

One of the main vehicles envisioned for monitoring and stimulating implementation is contract research. Microcomputers in education has already been designated a strategic priority within the ministry's contractual research program. As indicated in excerpts from our interviews, the rationale for research is based on the need to further clarify the actual effects of the technologies on students, teachers and schools, and the most effective ways of using them under varying organizational conditions.

We need to put research back into the system about the use and impact of these technologies. Research on good applications, good usage, success and war stories need to be fed back into the user network to have an impact as it evolves.

We need to allow new models to evolve...Observe them...Do formative evaluation...And then generalize across to large numbers of teachers.

The broad picture, then, is that research on NET implementation and effects should be conducted in the field (both in terms of contract research and pilot projects), that the findings should be funnelled back to innovation developers and users, and that access to such information will result in ongoing modifications and refinements in the innovations and their uses. Presumably such data will also influence ministry-level decision-making and problem-solving.

The scenario described presumes a high level of research-based knowledge utilization at the local and provincial levels. It also presumes a high degree of openness to ongoing change in innovation use. From what we know about knowledge utilization in schools (Fullan 1981), and about the developmental nature of change in practice among teachers, both presumptions are on shaky ground. Research by Hall and his colleagues on growth in teachers Levels-of-Use of educational innovations has shown that with appropriate support and time, most teachers settle into a routine pattern of use (Hall et al. 1975). While some will make ongoing refinements to increase student impact, very few will actively initiate or seek out major changes once things settle down into a new routine. Our point is that the image of ongoing adaptation of NET use, based on the availability of information about more successful products and uses, probably underestimates the inertia to further change which is likely to settle in at the school and classroom levels after the initial period of implementation.

Ministry officials do not see implementation monitoring solely as a provincial responsibility. The ministry has arranged with the OEES and with GEMS vendors to maintain user "hotlines" to identify and help resolve technical problems with the software and machines in the field.

While the need for implementation monitoring at the local level is recognized, the sources consulted for this report did not give us a clear picture of ministry expectations in that regard. Recommendations for planning for computers in education at the local level in Policy/Program Memorandum No. 72 simply state that school boards should specify "the evaluation methods to be used with programs" and "the methods of identifying and monitoring changes in teaching/learning patterns". A more recent statement of ministry expectations makes no reference to formative evaluation of implementation progress and problems (Advisory Bulletin on Computer Technology in Education, Policy/Program Memorandum No. 91, 1987). More generally, however, the Ministry of Education in recent public statements has made it clear that it will turn its attention increasingly to matters of impact and effectiveness in all policy and program areas. It is not clear at this time how this concern will be translated into the assessment of NET. The use of the Ontario Instrument Assessment Pool (OAIP) to assess NET related student learning may be one resource. In

any case, we can expect assessment to be a major component of future government initiatives.

Implementation Monitoring and Problem Solving: Up Close

Most of the field studies at our disposal were examples of the kind of in-house and contract research the ministry typically uses to document what is happening in the school system in relation to priority issues (Provincial Review Reports, Review and Evaluation Bulletins, contract research publications). While they provide important data on many aspects of local NET implementation, none had much of anything to say about how school system officials, central office consultants, or even principals, manage to keep tabs on what teachers implementing the technologies do in the classrooms/labs, and whether information on implementation progress and concerns get somehow fed back into organizational support for the change.

Larter et al. (1983) described the situation when microcomputers were first being introduced in the Toronto Board's elementary schools. In terms of communications about implementation, it is not a very promising picture. Teachers reported frustration and confusion about "fuzzy" communications channels in seeking guidance and help from the central office. In one characterization, the researchers described the overall situation as an "experimental preparedness context."

Within such a context, there are few definitive answers: instead dozens of ideas burst forth. Individuals in one part of the system may not know what those in other parts are doing and thinking; individuals at all levels may frequently change their minds about how to use the innovation and much of the evidence regarding the advantages and disadvantages of the innovations is of an anecdotal nature.

According to the authors, individuals at all levels must be "willing to experiment" in order for this context to exist and be maintained. This image seems to correspond to the ministry view that there should be ample latitude for variation in use initially. What is missing is the second dimension of that view - that

information on what is happening, what is working and what is not should be systematically gathered and disseminated with an aim towards building increasingly convergent knowledge about best practices. Instead, we get a picture of "anecdotal" craft knowledge about microcomputer use in education trickling through the informal communications network of routine social interaction.

Lee's inservice follow-up study of microcomputer lab use in four elementary schools provides interesting data on the monitoring issue (Lee 1986b). Principals and/or staff in all four schools set up equitable and reasonably practical schedules and scheduling procedures for lab use. Lee concluded that differences in the lab schedules did not explain the observed high utilization of the labs in two schools, versus low utilization in the others. One of the critical differentiating factors turned out to be that the principals and staff in high use schools had set up procedures to monitor use of the lab, to communicate with each other about needs for scheduling changes, and were actively doing just that. In low use schools, nobody took responsibility for seeing whether the labs were being used as scheduled, and for communicating with others when the lab could not be used as planned. As a result, the labs were often vacant, despite the fact that a teacher had reserved the time.

One other significant bit of information on implementation monitoring surfaced in the field data. An OISE researcher confirmed that principals in boards where she worked really are caught in a quandary of accountability for what teachers are doing with the technologies, but not knowing how to evaluate it (see Principals Leadership).

There is clearly a need for research to document working models for implementation, including the mechanisms created to monitor and use information about implementation progress and user concerns at the school system and school levels. At a more generic level, the present increase in the development and use of Curriculum Review, Development and Implementation (CRDI) models, and performance appraisal procedures at the local board level, can serve as basic support and monitoring systems for all innovations including NET (Fullan, Anderson, Newton 1986).

8. Principal's Leadership

Much research points to the critical role of the principal's support for implementation of educational innovations at the school level. Effective implementation depends on the principal taking an active role in initiating and/or responding to change efforts within the school. Principals who are successful managers of change may be directive or responsive in their approaches, but they cannot just leave the responsibility to adopt and carry out changes to their teachers.

Principals need to be knowledgeable about innovation goals and expected uses in order to understand the needs, progress and problems teachers experience during implementation. While they may choose to undergo training and become users themselves, and to become directly involved in providing teacher assistance, participation at that level is not essential, so long as the principal provides access to resources, training and assistance from others. Research indicates that principals often depend on assistance from a "second change agent" in the school -- e.g., a vice-principal, a key teacher, a central office consultant -- especially in secondary schools.

Teachers are unlikely to change (i.e., to experience the conditions necessary to stimulate and support change) if the principal does not communicate clearly at the outset and during implementation that the change is a priority, that intended users are expected to follow-through, and that opportunities and resources will be available to resolve problems encountered during implementation. As in the case of central administrators, the principal cannot get away with mandated use in the absence of user assistance and shared power during implementation.

Research indicates that effective principals have good visions of what the school should be accomplishing for students. They use external innovations as opportunities to further those aims. Successful implementation does not require that the innovation be a "separate" priority, so long as it can be tied into priorities already targeted by the principal and staff in the school. Overall, the principal must create a positive climate for change by attending to the following components of the change process:

- initial and follow up in-service
- consultative assistance during implementation
- user planning time (during early implementation)
- user interaction and problem solving
- latitude for risk taking, errors and gradual mastery of new practices
- protecting users from undue demands
- holding users accountable for the change
- recognizing/rewarding user efforts

PRINCIPALS LEADERSHIP.

Broad picture: Changes for principals are uncertain, but are likely to involved new models for evaluating instruction and administrative uses of the technology. Principals need to be familiar with the innovation and to provide a supportive climate for change. They need to encourage experimentation in use and to help guide teachers towards effective practices.

Up close: Principals as a group are less enthusiastic and prepared than many classroom teachers. Wide variation exists in principals' commitment and active support to teachers. Those using the technology for administrative purposes are more likely to support teacher use. Local success stories point to active leadership of principals in establishing the priority, raising funds, planning personal learning, arranging professional development and release time for teachers, getting teachers to help each other, scheduling computer time, arranging facilities, and building parent support. Principals' concerns center on product selection, ensuring equal access, fair resource distribution, competing priorities, and teacher supervision. Administrative naivete about cost implications of NET use in the school is common.

Principal's Leadership: Broad Picture

Policy documents concerning NET implementation have little to say about the role of principals in the process. In our interviews we asked ministry officials to comment on changes for principals and their needs vis-a-vis their expected role in implementation.

Our sources varied in their opinions as to the magnitude of the change for principals. While some see little difference, there are three areas of change upon which there is general agreement. First, and most importantly, that principals will have to learn new ways of evaluating learning going on in the classroom--both the effects of computers on students and the effectiveness of teachers in using the technologies. They also agree that there are as yet no good models for doing so.

Second, most expected information technologies to be available to handle a lot of the principal's record keeping and paperwork. If principals implement that change, it gives rise to a third area of change. Relieved of some of the burdens of administrivia, principals, may be able to address other priorities. There is no consensus, however, on how he or she would use the time -- e.g., focus on school community relations, spend more time in the classroom, lead implementation planning and monitoring.

Ministry officials generally agree that principals are key agents in the success or failure of implementation in schools, especially at the elementary level. Principals need "to understand what NET implementation is all about" and "to be familiar with use of the machines" though they do not have to be resident experts. Most interviewees emphasize the need for principals "to encourage" teachers to get involved and use the technologies, to "be flexible" and encourage "experimentation" in use, and "to guide" them towards those practices that seem most effective. The principals basic implementation role would be to assist central administrators in creating a supportive climate for change. Being supportive includes trying to accommodate teacher needs for time to learn and plan for implementation, and giving positive reinforcement to those that try. Overall, the interviewees suggested that the task facing the principal is not all that different from that involved in other curriculum changes.

Principal's Leadership: Up Close

In the documents consulted for this report little was actually said about the experience of principals in the initiation and implementation of microcomputer use in schools, although most studies cited the importance of principal support.

In their 1982 study of the introduction of microcomputers into 115 Toronto Board elementary schools, Larter et al. (1983) found that principals on the whole were "less enthusiastic and prepared than many regular classroom teachers." The newness of the technology and the suddenness of its arrival into the school caught many unprepared. Few had prior experience and many were busy with other priorities. Of course, there were some who were eager to get involved, despite their lack of knowledge, and others who were already computer literate and committed to implementation.

The study did not examine closely how principals participated in the change. References are made to the support of principals in fund raising, helping timetable student access to the machines, and giving teacher latitude to experiment with different uses of the technologies. One difficulty noted concerned the emergence of resident computer experts in the schools, who frequently took on important responsibilities for coordinating computer use in the school and assisting fellow teachers. In some schools this led to confusion about lines of authority and who should make the decisions about microcomputers, particularly when the principal lacked computer knowledge and interest. The researchers recorded the use of machines for administrative purposes in some schools, but did not delve into the actual implementation and effects of that change for principals.

In their study of Logo-use by 13 teachers in nine schools, Carmichael et al. (1985) gathered some data on principals' support for project teachers and microcomputer use in general. Considering the small sample, they found wide variation in principals personal interest and involvement in learning about microcomputers, active support to teachers, and leadership concerning the general use of computers in the school. Four of the principals attended Logo workshops or general in-service on microcomputer use, in addition to facilitating staff training. Two were non-users, but strongly encourage staff to

take advantage of inservice opportunities. Two others showed interest, but basically left it up to teachers to carry out the change on their own. One gave little support and little interest until parents initiated a fund raising drive. The researchers found that project teachers "felt more secure trying out new ideas" where their principal gave active support, and that principals' "leadership in terms of igniting enthusiasm and in drawing out expertise among teachers seemed crucial in the increased acceptance of computers."

During this study, two of the less committed principals became more interested after they began to find administrative uses for the technology. In a study of the adoption and implementation of microcomputers in 12 school boards in the States, Yin et al. (1986) also found that implementation spread more quickly in schools where microcomputers were being used for administrative purposes as well. Thus, it seems that assisting principals with use of the technologies for their administrative function as may be a useful strategy for increasing the commitment of principals to use of the technology by teachers.

Carmichael et al. documented a number of concerns of principals regarding microcomputer use in the schools: need for guidance in making sense of hardware/software alternatives; diversion of attention and resources for existing priorities; fair distribution of resources to teachers and pupils; the number of fund-raising events going on. They also found that due to their lack of knowledge about the field, several principals failed to anticipate the ongoing costs and supply needs associated with NET implementation. The Larter et al. (1983) study documented similar naivete about the supply needs and ongoing budget implications of implementation at the school level.

The 1983 Pilot School Projects Report provides additional information on the roles of principals in microcomputer implementation. The increase in teachers using microcomputers for instruction during the project (time span unstated) was phenomenal in all schools. In one elementary school with a staff of 27, for example, the number of users jumped from 1 to 26. In a secondary school the size of the teacher user group grew from 3 to 21 (total staff of 55). Similar increases were recorded in the other three settings. The situations described, however, were clearly showcase sites for the introduction and use of the technologies in the sample boards. As such, the level of central and building

level support, teacher interest and quantity of equipment supplied was probably atypical even within the participating school systems. The following list summarizes the kinds of support given by principals in all three elementary schools.

- leadership on project steering committees
- giving high priority to the project in the school
- facilitating staff development, including provision of release time for training and meetings
- getting early users to train other teachers
- reorganizing school timetables to schedule student access to computers
- ongoing communication with all parents and support for involvement of interested parents
- maintaining open-door policy for visitors
- rearranging facilities to accommodate implementation

Curiously, the study gives no indication of the role played by principals in the two secondary schools, apart from participation on project planning committees. Nor is there information about the particular needs of concerns that principals had, or the kinds of changes they themselves had to make in the context of implementation.

Both of these studies focussed on the introduction and use of microcomputers and software prior to the development and distribution of GEMS and OESS materials. Lee's (1986b) inservice follow-up study of microcomputer lab use in four schools is our only example of systematic research on the role of principals in schools attempting to use GEMS (ICONS). The principals in all four schools effectively pressured teachers to opt into the initial 16-hour inservice program and to try out the labs with students during the first year of implementation. Based on data from her observations, interviews with principals and with teachers, Lee concluded that principals in all four schools applied little if any pressure to use the computer labs the following year. Nonetheless, they all continued to provide general support, in terms of money to buy needed supplies and access to additional consultative assistance (workshops, one-to-one

meetings). Despite these similarities in administrative pressure and support, the scope and frequency of computer lab use differed substantially between schools. While Lee's data are incomplete, they do suggest some important differences in what principals in high and low implementation schools were doing. The principals in high use schools, for example, encouraged teacher use by appealing to teachers not to deprive students of this potential learning opportunity. In the low use schools, the principals did not emphasize the benefits to be gained by students. Further, while none of the principals openly pressured teachers to use the labs, principals in the high use schools were unambiguous in supporting computer lab use as a school-wide priority. In the low use schools, the principals' initial verbal support for lab use was not interpreted as a serious priority by teachers, and subsequent lack of sanctions for non-implementation confirmed this impression.

In our view, the differences in the way these principals responded to the board's microcomputer initiative were probably not peculiar to the innovation. They seem consistent with the different management styles of principals described in the literature on effective principals (e.g., Leithwood and Montgomery 1986) and academically effective schools (e.g., Purkey and Smith 1985). Berman (1986) also identified variations in school leadership as one of the important foreground conditions influencing the implementation of educational innovations. In short, innovation implementation is more likely to succeed in schools where principals have already established a high priority on improvement in student learning, where resources such as external innovations are seen as opportunities and used to further this goal, and where norms of active peer collaboration in school improvement are in place. The situations described by Lee for the high implementation schools seem more consistent with this image than the low use schools.

We did not have access to additional information specifically related to the role of principals in implementation of GEMS/OESS. The 1986 TVOntario surveys, for example, asked teachers about the presence, status and services of in-school resource people, but did not inquire about the supportive activities of principals. It is further of note that none of the studies reviewed reported any concerns among principals regarding teacher supervision, any time savings as a result of using microcomputers for administrative paperwork, or alterations in

principals' behaviors stemming from such time savings. One of the OISE researchers interviewed, however, did offer confirmation of the teacher evaluation dilemma anticipated by ministry officials.

Principals are concerned that they don't know how to evaluate the effects of computers and the effectiveness of teachers using computers. And they feel a tremendous accountability to the board that they should be able to report back.

9. Community Support

Research indicates that implementation of most educational innovations proceeds without much community awareness and involvement. But when community members do take an active interest in the adoption and implementation of particular innovations, their support for or against the change is likely to be a major factor in local decision-making and commitment. In short, if parents actively support the change, boards and administrators are more likely to make it a priority, apply pressure and commit resources, and teachers are more likely to give it a try. On the other hand, active parent opposition can easily thwart implementation, no matter how good the innovation is or how committed school personnel are to its use.

COMMUNITY SUPPORT

Broad picture: Widespread community support exists for the adoption of microcomputers in schools. Parents may be more committed to having their children learn about computers than with computers. Public education about educational uses of the technology is needed to gain support for implementation.

Up close: Widespread parent acceptance and support exists for microcomputer use in schools. Active parent support stimulates teacher acceptance of the technology. Parents are involved in fund-raising, hardware/software committees, classroom volunteer work, and teacher training. Parent expertise with the technologies is not based on familiarity with GEMS and OESS materials. Parents are concerned about the impact of NET use on basic skills. Home-school communication is essential, but difficult because most parents and teachers have little experience with the technology.

Community Support: Broad Picture

The following quote from one of our interviews with ministry officials captures the essence of how community support for microcomputer implementation is seen:

One thing different about this movement is that it is largely bottom up. There is a spontaneous appreciation in the public of the importance of the technology. The public thinks computers should be in schools and kids learning about them, though maybe not for the same reasons as us. In the face of that interest, teachers feel pressured not to reject. They have to accommodate. That bottom up pressure is lacking in most guideline situations.

Community interest and support, thus, is perceived as one of the major factors contributing to the adoption of microcomputers in schools. Paradoxically however, that same interest is not necessarily seen as a positive force for implementation of the ministry's goals for use of the technology in schools:

We have to decide what we want kids to learn. And then we have to convince the public that it is learning and that it is worthwhile.

If you can convince parents that the basic content is being taken care of then it would free up time for other things. Many officials and parents still have a 'show me' attitude towards the educational uses of microcomputers.

The concern expressed by these interviewees is that parents may be committed to having their children learn about computers, but it is not clear that they understand what it means to learn with computers. Consequently, the high level of community interest represents a potential problem that cannot be ignored in the implementation of microcomputers as creative learning tools across the curriculum. Ministry planning documents call for expanded communication efforts to the public to educate them about the educational uses and benefits of the technology and to gain their support for implementation.

Community Support: Up Close

The field data reviewed affirmed the picture of widespread parent acceptance and support for the general introduction and use of microcomputers in schools (Pilot School Projects 1983; Larter et al. 1983; Carmicahel et al. 1985). Larter et al. found that "even parents who do not have a microcomputer at home, cannot program, do not use microcomputers at work, and have no knowledge of the machines whatsoever are still interested for the sake of their children." Student access to the technology is the most frequently cited parental concern.

The most tangible indicators of parent support are their reported initiation and participation in local fund-raising to buy hardware, and the high level of computer oriented volunteer work on board-school computer committees and in the classroom (pupil supervision, tutoring, extracurricular activities). Classroom assistance is most prevalent at the elementary level. Schools have taken advantage of available parent expertise for assistance in introductory teacher training and local software selection/development, as well. Carmicahel et al. give a good example of the effects of parent pressure to adopt the technology. Other teachers and the principal in one of the Logo-study schools essentially ignored the efforts of the project teacher until parents took on a fund raising drive to make sure the machines did not go away once the project was over.

While reports of active parent involvement in the classroom, software development and staff development sound positive, it is not at all clear whether and how parent participation might help in the implementation of GEMS and the new OESS software. To begin with, no parents will have access to that type of hardware at home or at work. There will not be community experts in the ICON comparable to the experience available for assistance with Apples, Commodores and so on. Furthermore, given the uncertainty about the educational impact of the new software, and the reported need of students for close guidance and supervision to exploit their creative potential, the models of parental help that have already evolved may no longer be appropriate.

The field data do not provide a good sense of parent expectations for use of the technology in the schools. Larter et al. (1983) recorded high parent interest in

the acquisition of general computer literacy and programming skills. Two of the studies reviewed (Pilot School Projects 1983; Carmichael et al. 1985) document concerns of some parents that computer use would detract from effective coverage of the regular curriculum. Parent objections to the use of computer games and concerns about possible health hazards are also noted. There are no data available at present concerning the receptivity of parents to GEMS, OESS materials and their proposed uses.

A very positive side of parent support is the reported encouragement many parents give their children to learn about and use microcomputer. This encouragement manifests itself in such ways as buying home computers, sending programs from home for kids to work with at school (both of which are problematic with GEMS/OESS), attending continuing education courses to become computer literate themselves, and the previously mentioned volunteer work.

School system/school strategies to educate parents and gain their support for school-level NET adoption and implementation include involving parents on computer committees, parent night displays/demonstrations, open house policies, parent in-service on school projects, presentations to parent/community groups, communications about school efforts through print and other media, and helping parents get training for themselves. Case studies in the Pilot School Project report suggest that more effective approaches combine various types of parent support generation strategies. Larter et al. caution, however, that because so many parents and teachers are novices in this field, and because central policies about microcomputer use are often vague, the potential for misunderstanding is great.

10. Environmental Stability

The outcome of implementation is susceptible to the influence of changes in the general organizational and social context. Frequent or unexpected changes in administration and project leadership, for example, can have a devastating effect on the continuity of a change effort. Career advancement of key personnel is common, both as a result of opportunistic motives and innovation success.

There is also a great deal of routine shuffling around of principals and support staff in some school systems without much regard for project continuity. It is easy for central administrators to create environmental instability by forgetting about local school context.

The negative effects of turnover in key personnel can be minimized by ensuring that responsibility for implementation management and support are spread among various people, by institutionalizing the responsibilities in the positions, and by considering project continuity in the criteria for administrative transfers.

Other important features of the local and macro-environment include such phenomena as major shifts in government policies, alterations in implementation relevant technologies, demographic changes in student populations, economic trends affecting the availability of funding, and public opinion. Finally, one can never anticipate all the "normal crises" that can inevitably occur during the course of implementation (e.g., flu epidemic, snow storm on workshop day, teacher strike). The basic message is that organizational support for implementation has to be flexible and tenacious enough to deal with unexpected turbulence in the local and broader environmental context.

ENVIRONMENTAL STABILITY.

Broad picture: The education system must adapt to the changing educational needs of a society increasingly based on information. The technology itself is unstable, due to rapid improvements and new inventions. Standardization of the software environment has not yet been accomplished. So each generation and brand of the technology requires another layer of implementation. The level of government funding for NET implementation is not assured over the long-term.

Up close: Rapid changes in technology quality and cost inhibit local planning for NET adoption and implementation. Supplies of equipment and materials are vulnerable to instability in the private sector. Major shifts in local project preferences are occurring with uncertain impact on implementation. Effects of changeover in first generation computer resource personnel are not yet felt. Changing teacher assignments during early use drains teacher energies away from implementation.

Environmental Stability: Broad Picture

The issues of environmental stability identified in ministry documents and interviews, as might be expected, focus on the macro- as opposed to the local implementation context. They include the ongoing transformation to an "information society", the introduction of additional new information technologies, rapid changes existing technologies, and the long-term stability of funding for NET.

A basic theme underlying the rush to NET implementation is that the economic base of Ontario, Canada and the Western world is increasingly dependent on the management and utilization of electronic information technologies and other forms of computer applications. The relevance of public education to the knowledge, skill and attitudinal requirements of living and working in the computer age is under serious question. The problem is that no one really knows what areas of the economy and home-life will undergo significant technological change, and what the education system should be doing in response to or in anticipation of those changes. Ministry officials express fear that the education system might come to be seen as out-of-date. In short, the educational and training needs of society are in a highly uncertain state of flux, and there is a real concern that the survival of the public education system depends on its ability to adapt to those circumstances.

A second issue concerns the continuing invention of additional electronically-based technologies with potential applications for education, such as compact disks, video disks and communications networks. Each new invention carries its own implications for change in materials, practices, beliefs and attitudes in the classroom and school.

The instability of the technology arise from rapid improvements in existing products as well as the invention of new ones. One official estimates major changes in technology within the private sector every five years. Some of these changes could make implementation simpler, e.g., reduction in the mechanical knowledge needed to use microcomputers. Others imply modification or replacement of materials and another round of unlearning and learning to use the technology. For example, the upcoming Stage II Functional Specifications

will require GEMS to have greater storage capacity and allow integration of video sources into screens and overlay with computer graphics. Increasing sophistication in software design and applications suggest that training in software use may have to be ongoing to keep step with those advancements. In other words, each "generation" of implementation. The allure of the technology and its potential for education makes it easy to overlook the danger of implementation overload for teachers.

Despite the push towards a portable software environment, the reality is still incompatible hardware and idiosyncratic software, even among alternative GEMS. It seems by no means certain that the desired degree of inter-product technical stability will be achieved as a result of the Stage II Specifications. As one ministry official pointed out, the impact of these requirements on the microcomputer industry has its own uncertain implementation context. Manufacturers of systems meeting the ministry's functional specifications, however, are collaborating with the government on this issue.

Funding to support the continued development and introduction of micro-electronic technologies in education is another area of potential instability in the macro-environment. The basic view is that education funding in general is in a period of contraction, due to reallocation of government resources to economic restructuring and demographic aging.

Environmental Stability: Up Close

The field data give some insight into the occurrence and effects of changes in the local or macro-environment for NET implementation on the schools. These can be grouped under three themes -- instability of the technology marketplace, uncertainty of continued funding, and staffing changes.

From the consumer point of view, the microcomputer hardware market is unstable, both in terms of rapid changes in quality and cost as new products are invented and others improved, and in terms of assurances of a continued supply of equipment from particular vendors. According to one of the OISE researchers interviewed, some school personnel are waiting "to see what else

might be available down the road". Lee (1986a) provides a good example of lack of product certainty brought on by a production shutdown and the recent availability of ICONs.

Prior to the coming of the ICONs, 32K PETs were used in many schools in the Board. Teacher evaluations indicate that about 48% of teachers in the four schools studied were planning on using or were using PETs in their classroom. In the newly constructed school there were no PETs available for use at all. This was understandable considering that Commodore Business Machines had discontinued the production of 4032 PETs back in December 1984. Monthly publications of the hardware PET RAP newspaper terminated in the spring of 1985. Similarly the PET Software Evaluation Committee ceased to exist to evaluate the purchase programs for the PET as of June 1985...The Board had withdrawn much of its financial support from the PET and directed the bulk of its computer budget to the new OAEM (Ontario Approved Educational Microcomputer).

The in-service training laboratory studied by Lee was originally developed to help teachers "use PET hardware and software presently available to schools". After the ICONs arrived, it was redesigned to focus on use of the new systems and software. Based on her school observations and on the withdrawal of central direction and support, Lee concludes that "it would be unreasonable to expect teachers to continue to use the PETs if PETs are marginally supported with repairs only, without additional software or other resources and encouragement". This is not a criticism of the board, rather an illustration of the causes and effects of market instability.

This shift is exactly what the ministry expects. Up close, we see evidence of it happening, but its consequences for teacher disposition towards and use of microcomputers are not clear. Among the teachers participating in Carmichael et al.'s study of Logo use, some questioned whether it was worth the effort, given the uncertainty of continued funding and access to the technology. It does not seem far-fetched to suggest that teachers may have similar misgivings about future potential major discontinuities in hardware/software type, and the prospects for unlearning and relearning it requires. Lee (1986b), however, found that prior experience with PETs or other conventional microcomputers

accounted for little of the variation in teacher use of ICONS after the computer lab program and inservice got underway.

Most of the field studies reviewed did not have sufficient longitudinal data to detect the effects of turnover in key staff (e.g., consultants, principals, resource teachers) on microcomputer implementation in schools. Larter et al. (1983) found that help from unofficial "experts" among elementary school staff members was a key factor contributing to implementation. There was an element of uncertainty about what happens if and when these helpers leave, and the need to ensure that they train other teachers in the school so as to reduce the dependency on particular individuals.

Changes in assignment are common practice in elementary schools across the province due to changing enrolment patterns, pregnancies, new program requirements (e.g., French, Guidance) and so on. Carmichael et al. (1985) report on the effects of changes in teaching assignments on several elementary teachers during beginning implementation with Logo:

These changes placed very strong immediate demands on the teachers with respect to additional learning, exploration, and preparation time, which were in direct competition with the demands of exploring how to use the computer technology and Logo in these new settings.

The implication is that principals could provide teachers a great help during early implementation by trying not to change their teaching assignments (e.g., new grade, split classes, new subjects). Even after they became accustomed to using the technology in one grade level or subject specialty, however, the complexity of switching to another assignment may be more difficult than before, due to the large number of lessonware items under development for each grade level.

In summary, we do not yet know a lot about what macro- and micro-environmental factors can upset the implementation apple cart. But we do know that significant discontinuities in the selection of technologies is happening in some settings, with uncertain impact on teachers' attitudes towards beginning or continued utilization. We know that mastering NET initially is

difficult enough for most teachers; therefore it is necessary to protect them at least temporarily from avoidable assignments to new grades and subjects. We can also predict that changes in key personnel in the school (principals, computer resource teachers) and at the board level (computer consultants) will have a negative impact on teachers dependent on their support, if measures are not taken beforehand to diversify the expertise.

CHAPTER 4 DESIGN REQUIREMENTS

A good strategy for widespread implementation of microcomputers should rest on some clearly specified "design requirements" that specify both constraints/boundaries, and the criteria which a good design must meet.

Some of these requirements have already been foreshadowed in the preceding discussion of factors in effective implementation, and how they manifest themselves in the current NET situation. Here we develop an integrated set of design requirements.

One preliminary comment should be made: the design requirements make it clear that the implementation task looks relatively formidable, well beyond the expectations of most people who have been interviewed, and beyond those expressed in most workable strategy that is adequate. It seems quite likely that the present balance of funding for hardware, software, and implementation support will have to be reconsidered, with more weight given to implementation support than at present.

Constraints

The design of any strategy usually presupposes some fixed boundaries. In this case, the constraints appear to be:

1. Dollar costs. The strategy cannot incur dollar costs from the ministry over those formally approved. At present, however, precise figures are not available.
2. GEMS/OESS as central target. The strategy must focus primarily on the implementation of GEMS hardware (including ICONS and IBM) and the OESS software; efforts aimed at other computer applications (e.g., the prior grass roots implementation of 8-bit hardware and associated software) are includable only insofar as they lead toward better implementation of GEMS/OESS.

3. **Curriculum.** Curriculum time allotments cannot be expected to change -- officially, at least. Furthermore, new and revised curriculum guidelines will continue to be issued.
4. **Time boundaries.** The length of the school day, and the number of days officially available for professional activity will not change substantially.

Criteria for a Good Strategy

Based on the preceding analysis of implementation factors, and the current/projected situation of GEMS in the province, what can we say about the criteria for a good strategy? What will such a strategy have to look like, or include as essential components? We have identified 20 criteria.

1. **Local responsiveness.** The strategy must respect the local context, rather than being monolithic. Strategies must undoubtedly be locally planned and managed. No "standard", fixed strategy is likely to work in diverse settings. Multiple models are likely. To put it another way: the strategy will have to rely rather heavily on local energy, though that energy can and should be in part mobilized through ministry action.
2. **Initial acceptance of uncertain target.** The strategy must also take into account the uncertainty/indeterminacy of the implementation target state. There are no precise scenarios of what a "good" implementation would look like. There is similar indeterminacy for the role changes required of teachers, the classroom management setups involved, the nature of likely student outcomes, and how these outcomes can be evaluated.
3. **Provision for increasing target clarity.** As it proceeds, the strategy should support increasing degrees of clarity about implementation targets and outcomes. Potential and current users need to have images of what implementation actually looks like in various settings --classrooms, computer labs, libraries -- and what students and teachers are actually doing. Software quality and clarity is one aspect of this, but so is the more difficult goal of specifying effective instructional practices as part and parcel of quality software-in-use.

4. Learning maximization. Because even with increasing image clarity, both the strategic paths and the resulting implementations of the innovation will vary considerably, it seems essential for the strategy to be designed to maximize learning on the part of users, local boards and the ministry as to "what works". That means the strategy will have to include careful documentation at the local level, with steady monitoring of how implementation proceeds, problem-solving, assessment of the results, and sharing of the results internally, across boards, and with the ministry. The aim is to get an increasingly good sense of what effective practice looks like.

The ministry in particular needs a keen sense of what users are actually up against, so that it can carry out "backward mapping" to create a more effective set of implementation supports for what works in tackling the problems of implementation. At present ministry officials now have a relatively thin sense of what is involved in school-level implementation. Lee's (1986a) study showed that 16 hours of training is just a beginning.

At the local level, much learning and adaptation will be needed too. Board coordinators and consultants need to learn how to plan and manage the implementation process, and how best to help users. Teachers need to learn how to use the hardware and software themselves, how to manage classrooms to support student learning, how to develop increasing competence in new teaching styles involving the computer, and how to link computer learning experiences to the curriculum. A good strategy will have to maximize user learning, not only through formal "in-service", but through experimental projects, support groups, and other devices for getting better at what is being done.

5. Credibility high. The "sharing" part of the strategy must rely heavily on the credibility of those doing the sharing. For example, if a "lighthouse" strategy is adopted for sharing, then the lighthouse and those teachers in it must be seen as "like us", "not special", "trustable", etc.
6. Overload reduction. The GEMS/OESS "innovation", if taken seriously, represents a very demanding change for schools (see also comments below under time reallocation). It is as if teachers needed to learn to read, and to understand what a book is, at the same time as proceeding to select books, make lesson plans, and carry them out --all the while continuing with their other "normal" teaching activities. A good strategy

will have to segment implementation into simple, workable chunks, and probably work incrementally. Both the actual, and the perceived size and complexity of implementing NET will have to be decreased. Clear images will help; so will time reallocations (see below).

7. Intense, sustained, responsive assistance. The indeterminacy and demandingness of the innovation means that the strategy must include very substantial amounts of direct, close-to-the user assistance, fully responsive to problems as they occur. The assistance needed is not just technical, but educational, social, and emotional in character. The nature of the NET innovation means that assistance may need to be especially intense at the start, to help users reduce anxiety and increase familiarity with hardware and software use. There is always a substantial front-end learning period with any new software, let alone a new hardware system.

However, assistance will also need to be present steadily during implementation, not just at the beginning. Studies of "grass roots" implementation of microcomputers show that stabilization usually took at least two years. Users need plenty of chances to practice, try out approaches, get coaching and feedback, and continue.

Note, that the gist of this criterion is both to provide ongoing support and to keep the pressure on for responsive action. Yet both initial and continuing assistance must be feasible, more or less within existing resource constraints.

8. Expansion of assistance capabilities. It is clear that the ministry intends to "stand at arm's length" from implementation, and deliver little assistance directly.

Given this policy and existing resource limitations, it seems likely that the strategy will have to include a "leadership development", "multiplier" or "training of trainers" aspect. The development of support materials may also be needed to expand assistance capabilities. The ministry has a crucial indirect role in funding and stimulating the identification and dissemination of assistance resources and activities.

9. Support for user interaction. Much "assistance" is peer-mediated. A good strategy will need to make direct provisions for this -- for example, through durable learning partners (which works well with students as well), peer coaching, user support groups, and the like.
10. Clarity about principal's role. The strategy must also reduce the present uncertainty around a desirable role for principals in implementation, suggesting positive models for their behaviour. Most evidence so far indicates that principals are lagging "behind" teachers in their knowledge and interest in NET. The strategy must provide clear guidelines for such principal behaviors as coordinating/managing, pressure for use, support, setting a climate for experimentation and risk-taking, time scheduling, evaluation, and organizational "embedding" of the innovation.
11. Serious attention to time reallocation. The strategy will have to solve, or at least make provision for, the very substantial amounts of extra time the GEMS/OESS implementation will require. As one user said, "Computers are a time sink." Ordinary "in-service" will not suffice, since users also need time for (a) hands-on system familiarization; and (b) specific software familiarization (1) (both of which require substantial time on the computer); as well as (c) connection/integration with existing curriculum; and (d) classroom management planning. In most cases users have a "double preparation" problem: they are maintaining their existing teaching load in parallel with their microcomputer efforts. Furthermore, there needs to be time for the supportive social interaction noted above.

It seems likely that structural interventions into the school's work day will be needed. Even with these, note that careful attention will need to

1 "Software" is used here generically. It's important to remember that we are actually speaking of programs of many different types, with different associated learning requirements. These include, at least: (1) "tool" programs such as word processors, statistical packages, spread sheets, drawing programs, data bases; (2) general problem-solving or generic skill development programs, such as LOGO; (3) didactic programs centering on subject matter; (4) drill programs; (5) simulations; (6) games.

be given at the local level to the problem of competition for and access to machines; this will appear for both teachers and students.

12. Some early success. The strategy must also be designed to create some "early success", so that users and students feel rewarded by their efforts relatively soon during implementation. This is especially critical because of the problems of overload and indeterminacy. One of the key implementation requirements is how to reduce some of the early (psychological, technical) costs for teaching and to increase some of the early rewards.
13. Use of existing human resources. The strategy should build on existing energy, strengths, motivations, and capabilities, not only on the part of "resident experts", Board coordinators, teachers and administrators, but students, parents, and other citizens, and in existing informal networks (e.g., Educational Computing Organization of Ontario). Much of what has developed so far represents "grass roots" initiatives with a substantial momentum, which should not be lost.
14. Accommodation of old and new. There is an associated requirement: because a good deal of prior work on 8-bit machines has already taken place, the strategy must accommodate this work both initially and as it proceeds. The new and the old implementation have many inconsistencies, but they are addressing the same educational issues. The old work cannot be simply jettisoned, either practically or motivationally. The strategy must find a way to deal with old-new disjunctures productively -- both within the school, and because computers at home are often 8-bit machines.

It should also be noted that the strategy, at least in the short run, must accommodate differences between the ICONS and IBM hardware, and associated software -- and potential differences between this and the next generation of hardware.

15. Non-reliance on software perfection. In spite of the strong emphasis on software quality, it is clear from early field tests and much prior experience that there is no such thing as "perfect", self-operating software, or software that works independently of the classroom context and teacher interventions. The strategy must assume that software will have bugs, be in part poorly designed, fit some students and topics better

than others, and be in need of careful and discriminating teacher choice and action.

16. Accommodation of changing range of user types. Similarly, it is clear that the strategy must accommodate a wide range of present and potential users of the innovation. At a minimum, these include computer "enthusiasts" who are already using either 8-bit machines, GEMS/OESS, or both; "non-enthusiast" teachers who have been exposed to microcomputers; new users who are just beginning their implementation; and non-users, who are more or less distant and/or reluctant in their stance toward the innovation. Furthermore, the balance of these user types will be changing steadily over the next few years. An extra problem is ambiguity about the present balance: estimates of past users (including enthusiasts) range up to 74% in elementary schools, and up to 44% in secondary schools. Users of ICON systems are far fewer (11% and 17% respectively), and ministry estimates centre around figures of 20% or less.

A corollary of this diverse range of user types is that the implementation strategy as such will need to be accompanied by a "dissemination" strategy aimed at increasing awareness and interest on the part of the relatively large non-user group. It also seems likely that the needs and interests of elementary and secondary teachers differ, as does their current use.

17. Continuous updated training. The strategy, both for the reason just noted, and because of the continuing development of new software, must be iterative, allowing for steady learning and development -- retraining -- on the part of users.
18. Parent involvement. The strategy must build on parent interest and support for microcomputer implementation. Continued parent support will help ensure the maintenance of local and provincial funding, and will keep up the pressure on school personnel to implement. At the same time the strategy must deal with the legitimate concerns of parents about the ways in which the technologies are being used in the schools, particularly because of the high uncertainty regarding the educational benefits of using the computer as a learning tool, as opposed to simply teaching kids about computers.

19. Coordination among multiple agencies. The strategy must coordinate among the major agencies involved in the implementation: the ministry, local schools, board offices, universities, professional associations, TVOntario, hardware and software producers, and others. It should maximize the useful contribution of each.
20. Visible Progress and Impact. Because of the uncertainty, high cost, high visibility and mystique of microcomputers, any strategy for implementation must focus on and produce results in the short and mid term. Initial enthusiasm and excitement may be sufficient for the honeymoon period, but must be supplemented before long by teachers' sense of mastery, competence, and confidence in using the machines and by evidence of sustained student interest, motivation, and learning achievements. There must be a strong confirmed sense over the next two years among the various stakeholders that "we are really getting somewhere". This need for tangible progress conflicts with the need for a slow start due to uncertainty about microcomputer uses and outcomes. Progress at this stage ought not be equated with rapid expansion of hardware availability in schools. The administrative focus initially should be on progress in creating an infrastructure to support implementation. And users should be helped to think of progress in terms of adaptive learning, i.e., learning to make the technology work well for teachers and students. All stakeholders will have to orient themselves initially to the search for better and better ways to use the technology. Learning about the impact on and outcomes for students is essential to this search.

In summary, most of the criteria we hold as important zero in on developing NET-in-use. The criteria essentially (1) stress the need for further, careful development of the innovation (the characteristics of the innovation (factors 1 - 3 in Table 2), (2) place strong emphasis on the required professional development learning experiences (factor 6), and (3) identify the additional supporting and pressuring conditions for stimulating quality implementation (factors 4,5,7,-10).

CHAPTER 5 STRATEGIES FOR IMPLEMENTATION

Given the problems of implementation and the requirements outlined in Chapter 4, what approaches to implementation would be most productive? In this chapter, we develop an interrelated set of strategies through the following sections:

1. What is a strategy
2. The policy aim
3. Useful strategic types
4. Recommended strategic streams
5. Time line and strategic management
6. Critical review of the recommended strategy
7. Next steps

We begin with a brief overview of the idea of strategy itself, followed by a review of the policy aim for the implementation of microcomputers in Ontario schools. Then we outline some general strategic types that are likely to be most appropriate for the task at hand. To sharpen this picture, we also discuss what strategic types we do not recommend, and why.

Next we proceed to the general strategy itself. We discuss six main strategic thrusts or "streams", all of which we believe are needed for effectiveness: (a) competence development, (b) consultant development (c) stimulation/facilitation of naturalistic efforts through planning/implementation grants and pilot/demonstration projects, (d) diffusing and supporting effective practice, (e) support for networking, and (f) organizational capacity-building. (We quite deliberately do not suggest a minimum strategic floor, with "desirable" additions. Rather, a full-fledged approach to implementation requires attention to all six "streams".) The balance of emphasis and resources among the six, and the specific components chosen within each stream, must be continually assessed during operational planning.

For each strategic stream, we outline the specific components that would be involved, then summarize what would be happening at the

ministry/regional/associated agency level, and then at the board/school level. Naturally, the six strategic approaches will be interconnected, mutually supporting and reinforcing (or inhibiting) each other. We comment on this interconnection along the way. In a summary section we propose an over-all time line and management of the entire enterprise.

We then assess the strategy using the design requirements outlined in Chapter 4, and comment on what would be needed for the strategy to be successful.

The section concludes with suggested next steps. What will be needed for the advice in this report to be transformed into a workable operational plan?

1. WHAT IS A STRATEGY?

For clarity and simplicity, we draw here on Hammer & Loucks-Horsley (1985), who proposed a straightforward model drawn from school improvement experience in 14 OECD (Organization for Economic Cooperation and Development) countries. It appears in Fig. 2.

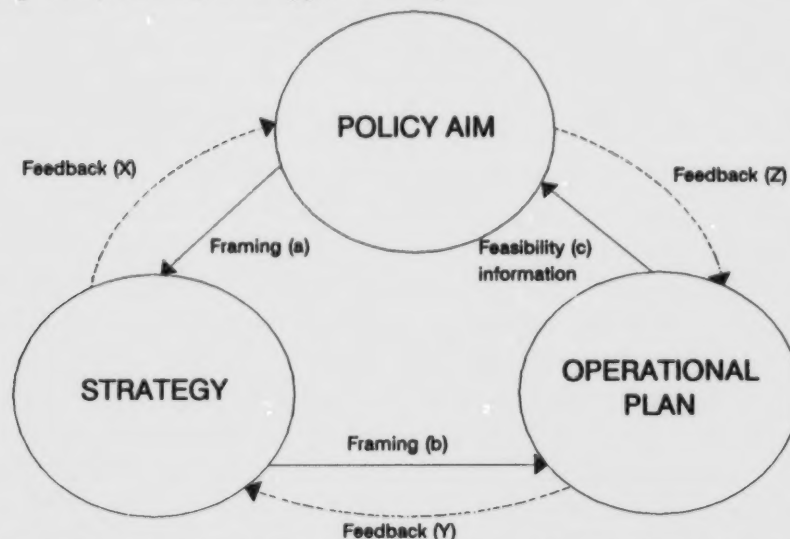


Fig. 2: Transformation Cycle among Policy, Strategy and Operational Plan (From Hammer & Loucks-Horsley, 1985)

A "strategy" as such is a sort of prescriptive design, which serves to guide action in a purposeful, interconnected and coherent way. As such, it mediates between a policy aim or intention, and a concrete operational plan. The policy aim services to "frame" or guide the development of the strategy; as the strategy is formulated, it typically has back effects on the aims through feedback. The strategy in turn serves to frame the operational plan, the shape of which also may well induce strategic adaptation and reformulation. And the early

	<u>Strategy</u>	<u>Operational Plan</u>
WHAT?	What is the aim of the improvements?	What will be done to carry out this aim?
WHO?	Which organizations and roles will be involved?	Who will be involved in each of the activities?
HOW?	What is the general nature of the activities?	What specific activities will be used?
WHEN?	What is the time frame for the improvement effort?	In what phase of the change process will each activity occur? When will each take place?
WITH WHAT RESOURCES?	What kinds of support will be needed?	What funding, personnel, facilities, materials, time will be needed for each activity?

Table 3: Questions involved in the design of strategies and plans (after Hammer & Loucks-Horsley: 1985)

implementation of the operational plan provides feasibility information that in turn has back effects on the policy aim -- which over time normally influences the evolution of the plan as well.

Normally, a strategy includes answers to a series of questions, which are outlined in Table 3, along with corresponding questions about the operational plan.

87." The more important need, we feel, is to lay out strategic ideas as clearly as possible--illustrating them with specifics. But actual operational planning belongs to "next steps", after a reasonably clear consensus is developed about desirable strategies.

The simple framework above conceals a good deal of complexity. For example, the WHAT question usually requires discussion of the scope or size of the change and its outcomes; the WHO question must specify change targets (individuals, roles, groups, organizations); the HOW question may include analysis of the metaphors (such as "lighthouse", "pilot", or "network") that characterize the strategy, along with its basic assumptions and requirements for success; the WHEN question involves short and longer-run phasing, and complex interactions with the WHO question; and the RESOURCE question normally involves balancing a wide range of tradeoffs.

2. THE POLICY AIM

The policy aim that frames the strategic ideas in this section has been described earlier (Chapters 1 and 2). Here we will summarize it briefly as a backdrop for the strategic discussion that follows. It is likely, as suggested above, that this statement of aims will evolve further as strategic choice and operational planning proceed. Policy aims, this set included, usually (and even desirably) have a certain indeterminacy at this stage.

In brief then: the implementation of NET in Ontario has the following long-term aims: (1)

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- 1 The policy aim also includes economic goals, such as support of Canadian industry, and the technological goals, such as easy-to-use hardware and a consistent environment for software. We take these as given, and as having workable strategies devoted to them already. Our emphasis is therefore on policy aims that require careful strategic attention during implementation at the board and school level.

1. Every student in Ontario will have access to a microcomputer for a half hour a day. Equality of access is important.
2. The ratio of student to computers will be 10 to 1.
3. Computers, typically 3 or 4, will be in every classroom, not only in labs or libraries (the pattern may differ in secondary schools).
4. The uses of computers will emphasize creative learning (writing, designing, problem-solving, critical thinking) as much or more than drill, skill development, or subject matter mastery. There will be more emphasis on individualized learning approaches. It is expected that a well-developed software base of about 830 items will be available to further these aims.
5. The use of computers will be integrated into every area of the curriculum (not separated or specialized), will further existing educational goals, and will not emphasize "computer literacy" as a central goal--though that may be a by-product.
6. Back of items 4 and 5 is a tacit aim: administrators and teachers will be highly competent in supporting student use of computers as described. "Quality use" is the watchword. Such competence, it is believed, will mean substantial change for many teachers, both in their typical classroom roles, and the skills and understanding required.

3. USEFUL STRATEGIC TYPES

Implementation strategies can be categorized in many ways. One of the most basic involves planning assumptions. Many strategies assume a rational, programmatic, technocratic planning model, with specifically-designed steps, well built by a central body after extensive cost-benefit analyses and tight specification of aims.

It is very clear that such strategies will not work in the present situation. The precise end state of "good implementation" in terms of effective teaching strategies and activities for specific software is uncertain, as we have noted in the design requirements; moreover, the scale is large and the time line long.

There are many other uncertainties: how to accommodate the old and new, and wide variations in teacher commitment and experience with different types of hardware and software.

Thus it seems clear that a process planning or adaptive approach will be required, in which a variety of strategic initiatives can be launched; there should be a strong emphasis on learning from practical experience, and the approaches taken should be steadily influenced by concrete experience with them. We stress that learning from practical experience does not have to be haphazard. It should be strategically stimulated to maximize the linkage between good practices as they evolve, with dissemination, professional development and technology development. Since both quality and practicality of computer use are goals, and since the required teacher behaviors and classroom configurations are not known at this point, the strategies chosen must take a learning-oriented, developmental approach, in which good practice can be captured and recirculated. It should also be clear that the strategic streams are designed to take into account systematically the 10 implementation factors discussed in Chapter 3.

Strategies also differ according to their primary emphasis. The most promising strategic types for our purposes appear to centre around:

1. Competence development (enlarging and developing skills of teachers and administrators through training).
2. Consultant development (identifying local facilitators, enhancing their skills, and building a support structure for them).
3. Stimulation/facilitation of naturalistic efforts (supporting grass roots initiatives at the board/building level, including experiments, pilots, demonstrations).
4. Diffusing and supporting effective practice (disseminating well-developed practices and supporting users in implementation of them).
5. Networking (linking users within and across school and boards for mutual enhancement).

6. Organizational capacity-building (strengthening the ability of boards and schools to manage the multiple innovations involved in the change process; developing a good infrastructure of supporting agencies).

There are some other strategic types which are clearly inappropriate at this point. The most familiar one is mandating: specifying required changes in legal or regulatory terms, and following this with inspection and enforcement. Mandating (a) can hardly work well when end states are not known; and (b) the existing structure and traditions in the province are not congruent with it.

Another unworkable strategic type is the strict research, development, and diffusion (RDD) model. Grass roots use in the schools is already underway, and the ministry cannot and does not wish to limit access to new hardware and software until it is well "proven".

The strategy of local materials development (asking local boards and schools to develop teaching materials in a decentralized fashion, to enlarge local commitment and local relevance) is not wholly workable either, if software is the focus. The ministry has already made a strong commitment to professionally-developed software. It is not likely that sophisticated software development can be carried out extensively at the board and school level, even if the present encouragement of local software development skills is pursued further. In any case, local professionals with specialized interest and expertise can and do bid for software development contracts, but this is directed towards province-wide use.

We should note, however, that the strategy of local development can certainly be used in the generation of materials supporting useful classroom management and instructional strategies. Thus, funding boards to develop demonstration schools, or pilot schools focussing on effective practices would be highly desirable.

In the next section we discuss each of the six strategic types. The streams are seen as complementary, parallel and linked to teach other. Within each strategic stream, we propose workable components, specific activities that would take place over time.

The six streams form an overall strategy for implementing NET in Ontario schools. In the next section, we make 38 recommendations. Table 4 lists the recommendations according to the six streams.

4. THE STRATEGIC STREAMS

A. Competence development.

In this domain, we propose a blend of formal training approaches and at-the-elbow assistance. Some pre-service training is useful, but above all, active in-service training is needed (Fullan and Connelly, 1987).

We should re-emphasize here that effective training will have certain characteristics: it will be carried out by credible people who have used GEMS/OESS in classrooms; there will be demonstrations and hands-on experience in realistic settings; it will have follow-up practice and coaching; it will be locally-responsive and will reach within-school groups of users rather than isolated individuals, and support their interaction; it will occur both during early use and continued implementation (is sustained, not "one shot"); and will proceed incrementally to aid growing mastery.

The following components should appear in this stream. The first three are in effect ground-level learning tools needed to assure "entry-level" skills for teachers, administrators and consultants as NET implementation begins. Each of these basic workshops would be prepared in a standardized format and introduced on a multiplier basis to local resource personnel, who would then replicate the workshop as often as necessary with new groups of users in their home settings.

1. Development of a well-standardized orientation workshop format (perhaps 2 days), introducing principals and teachers to the use of GEMS and the Ambience, illustrating the use of one or two popular, easy-to-use, tried and true OESS programs, and sketching classroom and curriculum implications. These entry-level workshops would concentrate on learning to manipulate the hardware and interface in conjunction with either a basic utility software (e.g. word processing, graphics), or specific

pieces of lessonware (introducing several categories of software is too confusing for the initial experience). The workshop design would be adaptable to teachers from different divisions or subject specialties. This might sensibly be done through a contract involving collaboration between hardware vendors (recall that UNISYS and IBM already offer some introduction to using the systems), and OESS, using expertise from school boards, TVOntario, universities and OISE. It is critical that the workshops be fitted in to a local strategy of follow up assistance. The workshop would also be useful for any new entrants to in-service provision (university faculty members, for example).

Table 4: List of Recommendations by Strategic Themes

A. Competence Development

1. Development of GEMS/OESS orientation workshop
2. Development of classroom management workshop
3. Development of workshop series on planning and managing implementation
4. Development of principals' workshop on administrative uses of microcomputers
5. Revision of the AQ 3-part specialist course
6. Grants for development of in-service programs and follow up services
7. Encouragement of revision of existing in-service and pre-service offerings
8. Revision of Bits and Bytes course by TVOntario

B. Consultant Development

9. Design of a process for identifying and legitimating local consultants
10. Training of local consultants at regional centres
11. Design of a workshop series on helping and training skills
12. Development of a workshop on in-service training design
13. Development of a regional support structure for local consultants
14. Professional development of regular subject consultants
15. Linkage between NET and CRDI (Curriculum Review, Development and Implementation)

C. Stimulation/Facilitation of Naturalistic Efforts

16. Matching grants for pilot implementation
17. Matching grants for "conversion" projects (8-bit to GEMS/OESS)
18. Design of a system to support cumulative learning from pilot projects
19. Design of a documentation system for pilot projects
20. Grants for demonstration sites
21. Follow-on grants for local incremental expansion

D. Diffusing and Supporting Effective Practice

22. Design of a system for identifying well-implemented, effective local practices (review panel, developer/demonstrator grants)
23. Directory of approved practices
24. "Awareness" broadcasts by TVOntario; local awareness conferences
25. Development of contracts between developer/demonstrators and local boards
26. Annual meeting of developer/demonstrators and regional centre staff
27. Software evaluation
28. Design of methods for getting feedback on software from schools to assistance centres and software development staff
29. Help lines to OESS, software developers
30. Research on software implementation characteristics

E. Networking

31. Grant support for networking local pilots, implementation and demonstration projects
32. Mini-grants for local network development
33. Support for development of GEMS users associations
34. Support for continuing development of ECNO (Educational Computing Network of Ontario)

F. Organizational Capacity-Building

35. Retrieval conference on early implementation experience
36. Development of a workshop on project management skills
37. Grant support for organizational capacity-building
38. Ministry assessment of roles and abilities of key agencies

2. Development of replicable formats for a brief classroom management workshop, focussing on practical patterns of computer use, including the use of learning centres and labs. The workshops should also deal with the questions of integrating software and curriculum. These beginners workshops would be based on using software which has proven easy-to-use and effective with students in natural school settings. It is likely that different workshop formats would be appropriate for elementary and secondary teachers. These formats would have to be constantly updated and revised as more and more experience with classroom use cumulates (and as the number of microcomputer typically available to regular classroom teachers grows). Such formats could be developed through contracts with one or more boards where effective classroom (or lab) use of GEMS has already been occurring. Schools and boards doing pilot work would have attendance priority. Again, the expectation would be that board and school-level resource personnel might attend and replicate these workshops with beginning users in their own settings as part of the local professional development strategy for microcomputer implementation.
3. Development of a workshop series on managing and supporting implementation, aimed at teams of principals and local board and school-level computer coordinators. The emphasis would be on how local facilitators can best stimulate, support, and assess implementation. The series should extend over a school year, with practical local initiative interspersed with training sessions. The series should be developed in a pilot form immediately, and after a year's experience and revision be regionally offered by universities and OISE field centers, in collaboration with ministry regional coordinators, secondees and experienced local coordinators. We believe that the experience of developing and revising this series will do a great deal to enhance the practical knowledge and skills of the trainers involved, since it will bring them into close touch with the realities of school-level implementation.
4. Development of a course of workshop series for principals and their key administrative assistants, focussing on administrative uses of the technology. Principals using the technology for their own needs are likely to understand and give more attention to classroom implementation by teachers. Inasmuch as this involves the "business" functions of microcomputer use, the ministry might consider contracting the development of in-service packages through UNISYS, IBM or other private sector firms experienced in this kind of management training.

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School level administrative uses will be linked in part to board-level information systems. Thus, any in-service design should involve local collaboration and follow-through from the business, personnel or other appropriate organizational units of the board.

5. Universities should be asked to extend and revise the present Additional Qualifications 3-part specialist course in computers to emphasize GEMS and OESS applications, including highlighting implementation problems and strategies; for example, those discussed in this report.
6. During the first two years, small grants should be made to potential providers of training and consultative service (either external groups or boards themselves) to develop experimental/prototypical in-service training programs with the characteristics we have specified. They would normally include initial training (combinations of or alternatives to the more standard formats already described) and follow-up user service contracts building on the kind of entry-level workshops outlined in components 1-3. These programs could focus on learning to use specific items or types of software in actual classroom situations.⁽²⁾ The grantees would carry out the programs and document them. The experience with such programs would provide useful information about the type and extent of initial training and supportive follow-on assistance that seems essential and desirable.
7. The ministry should certainly encourage existing in-service (and pre-service) providers (for example, Ontario Teacher Federation, subject matter and professional associations, universities, community

2 The fact that microcomputers meeting the ministry's functional requirements are not being developed for the home computer market, and that software developed for use on GEMS is not portable to conventional home computer machines works against local competence development. Teachers (and students) with microcomputers at home cannot use them to work with the programs on their own. GEMS developers could be stimulated to create smaller home versions that parents and teachers could buy. The existing wellspring of parent expertise and support in the home would not be lost, and teachers would not have to depend on in school planning and practice time.

colleges) to revise and update content and procedures to be congruent with GEMS/OESS implementation. Much of this will happen naturally; it will be accelerated as such providers compete for contracts like those proposed above.

8. TVOntario should be asked to update/revise/rename the Bits and Bytes course to add GEMS/OESS content, de-emphasize "computer literacy", and reach parents and other citizens with clear messages about the entire initiative. Either within this or separately, TVOntario might also be invited to develop some videotape demonstrations of classroom use. They will not be aimed at skill development, (although they could be used for this purpose) which requires local planning and practice, but at providing alternate images of classroom utilization.

We should note that the components in this "competence development" stream are linked to other streams in the overall strategy. For example, at-the-elbow assistance is discussed more fully under the next stream, "consultant agent development"; it will also be an important part of the various types of matching grants proposed under the remaining four streams.

Reviewing this stream, we note that the ministry is seen as largely responsible for stimulating (through specific contracts) the development of good-quality, widely-usable training formats that can launch schools and boards in the direction of early success. Early development and use of these formats also helps to develop a cadre of effective trainers throughout the province, to engage other agencies, to develop a common language about GEMS/OESS implementation, and to strengthen the reality of regional assistance centres.

What will be happening at the board/school level? Essentially, local people who already have GEMS/OESS in place will be helping to develop and carry out these training formats. The next generation of new users--those beginning during the second and third years--will use the training formats actively in the launch and early implementation phases. Within three to four years, there should be a wide range of training and support resources available for boards and schools to call on during initiation, early and later implementation of GEMS/OESS.

B. Consultant development.

As we have noted, formal "training" is not enough. GEMS/OESS users will need direct at-the-elbow help as they proceed. That help can come from people called "coordinator", "facilitator", "expert", "resource teacher" or "technical assistant"; we use "consultant" for simplicity.

It seems clear that many schools already have "resident experts"--typically eager computer users who already have both interest and competence. Furthermore, many if not most boards already have computer coordinators and/or consultants, as well as supervisory officers with a special mandate to oversee computer developments. This stream of the strategy aims at using the energy and expertise of these people, and turning them into helpful local school-level consultants. The aim is to embed an increased capacity for assistance in the local setting. The needed components here are:

9. The ministry should design a simple process for identifying and legitimating local consultants. Initial priority should be on "resident experts" in school and boards with GEMS in place, and who have already had some direct classroom use experience. It seems likely that in any given board, there will be several "generations" of such consultants, as more and more experience with classroom implementation cumulates. The current conception of school-level "site administrators" is more oriented to the need for technical expertise with the equipment in schools, than to user needs for help in methods of use in the classroom. Successful implementation will depend on access to both kinds of help. The ministry should take steps to help clarify the selection and roles of in-school resource people through research publications (like the Pilot Project Schools report publications) and dissemination of sample position descriptions.
10. Initial training of local consultants should be carried out at regional centres, using the workshop components mentioned above. (GEMS, implementation, classroom management.) The ideal would be a team training approach, in which a board coordinator and several school-level consultants attended together.

11. The ministry should commission the design of a short workshop series in helping and training skills. Many individuals with strong interest in educational computing are not equipped to function as consultants, trainers or facilitators of adult learning and development. In fact, their technical enthusiasm may stand in their way as helpers. A number of training packages now exist in this domain, and a contractor could adapt them to the NET readily.

It is likely that helping skills training could initially be offered directly to regional coordinators and persons staffing proposed regional assistance centres, then by them to partners or teams drawn from local boards; board facilitators could then train other local facilitators. Given the problems of scale, it seems that a "cascading" or "multiplier" strategy of this general sort will be required.

12. A 2-3 day workshop on in-service training design should be prepared and offered to regional and board-level coordinators and consultants. The aim would be to improve these people's capacity in designing good in-service at the macro-level (program) and micro-level (single session). There are many management consulting firms with considerable experience in this area. The ministry could let competitive contracts for "training design workshops" much as it does for software development.
13. A regional support structure should be developed for local facilitators. The idea of an annual provincial conference of NET consultants focusing on implementation support strategies might well evolve (see also components under "networking" below).

Probably most boards will want to have a local support structure as well; the helping skills training should stress the development of local "cadres" rather than isolated individuals.

14. The burden of assisting teachers with NET implementation cannot rest solely on the shoulders of "computer consultants". The involvement and professional development of regular subject consultants is critical. The current generation's lack of classroom experience with GEMS/OESS materials poses a significant credibility barrier to their role as effective helpers in microcomputer implementation. Recruitment of subject consultants to participate in the entry-level workshop specified under the competence development stream is one strategy. In addition, the

ministry could contract with OESS to seek out subject consultants who are actively supporting implementation of relevant programs for the purpose of organizing orientation workshops for other consultants at professional association conferences. These workshops would be designed not just to introduce the software and demonstrate its use through videotapes or mini-case studies, but also to discuss the consultant role in NET support. Boards requesting grants for developing in-service programs and networking strategies (see Competence Development, Networking) should be encouraged to involve subject consultants as providers or beneficiaries of these efforts.

15. Boards should be encouraged to develop clear linkage between NET and CRDI (Curriculum, Review, Development and Implementation) planning and support. Computer coordinators and consultants cannot afford to be working in a vacuum. (This theme is also discussed in the next section on "facilitating naturalistic efforts"). This component's value is limited by the fact that only 40% of boards now have CRDI policies/plans in place (Fullan, Anderson & Newton 1986)--but there is no reason not to capitalize on existing local capacities, especially since CRDI use is growing.

Reviewing this stream, we see that the ministry will be devoting its main efforts to supporting the rapid local identification and training of consultants who can provide direct at-the-elbow assistance to teachers and administrators. Such consultants will need a regional and provincial support structure, which need not be elaborate, but is important.

At the board/school level, presently functioning "resident experts" will be getting a "license to practice". They will be receiving supportive training, and given enough work time to be able to work directly and closely with teachers and administrators who are carrying out early implementation activities. Users will know that there is someone there to turn to for support in dealing with questions from the apparently trivial to the basic: the domains of help will include use of the hardware, evaluating software, classroom management, linkage to the curriculum. Over the life of this initiative, these local consultants will become more and more professionalised. Traditional subject consultants will be given opportunities to develop their expertise in using and assisting in use of the

technology in their area, and will play an increasing role in implementation support over time.

C. Stimulation/facilitation of naturalistic efforts.

As noted earlier, this strategic type is probably central to NET implementation. The primary strategic aim is early, small-scale success: to get good-quality local implementation in a focused, limited way, as early as possible during the ten-year period--and to learn from this grass-roots process. The key components are:

16. A system of matching grants for pilot implementation projects should be initiated. These grants would be preferably made to local schools, or to boards; the matching feature (50% of funds needed), which is proposed repeatedly in this and following sections, is aimed at encouraging and supporting local initiative, mobilizing added sources of funds (boards, local communities) and signalling serious ministry support. The aim is to create a partnership between the ministry (including its regional offices) and local boards that support well-documented school level work from which everyone can learn cumulatively.

These matching grants would be for well-conceived experiments, with strong local formative feedback built in, and a requirement for thorough practical documentation of the experience, with emphasis on realistic problems encountered, the solutions developed for them, and the outcomes for students observed.

Such a system could begin immediately, and give preference to boards where GEMS installations are already in place, or where a good deal of 8-bit use has already occurred. Funding criteria should include emphasis on diversity and variation in approach; specify a range of domains for projects (department or subject-specific; classroom management-oriented; curriculum-linked; "creative learning" emphasis; tool-oriented--word processing, spread sheets, data bases, etc.) Priority should also be given, especially in early stages, to proposals from schools themselves, or to board proposals which emphasized mini-grants to schools. In any case, the direct participation of teachers and principals should be a requirement for proposal preparation. Proposals should also

provide for parent participation, both in proposal preparation, and in steering of the funded project.

17. In the first two years of implementation, a portion of the matching grants system should be directed towards "conversion" projects, in which classroom practices developed around 8-bit machines and software are adapted to the GEMS/OESS configuration. Proposals that deal with the most widely-used 8-bit machines and software should be given priority. So should proposals that provide for direct parent engagement.
 18. The ministry should design a straightforward system to support cumulative learning from pilot projects, capturing the expertise that develops. This should include regular "circuit riding" on the part of regional assistance centre staff; periodic regional "retrieval conferences" for sharing of experience; use of qualitative documentation reports, such as mini-cases or "vignettes;" analysis of all submitted proposals; (3) a contract for systematic analysis of submitted documentation; and linkage to evolving networks (see below).
 19. The documentation issues are so central that a documentation design contract should be let immediately, so that practical guidelines and alternative formats (case studies, vignettes, videotapes, structured descriptions) are immediately available to pilot grantees.
 20. In addition to the matching grant program, it would be useful to launch a modest grant program for demonstration sites. Past experience with the "lighthouse" concept has not been promising. Though visits and demonstrations are often helpful to prospective or new users, there are many difficulties. The usual problems include: instability or uncertainty about the new practice, compounded by overload and inexperience at handling visitors; tendencies to over-sell or over-"package" the practices; over-reliance on special funds to run the program being demonstrated; and lack of information on what the school did to get to its present
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- 3 Experience in England and Wales (Rabbett, 1986) was that approximately 20% of all schools per year submitted grant proposals for NET Implementation; analysis of proposal content was extremely helpful in further program planning.

exemplary state. All these problems reduce credibility (visitors are dubious about applicability to their own situation). Even when enthusiastic, visitors face the question of implementation follow through back home.

If careful attention is given during funding choices to such matters--and to linkage to the networking and diffusion/support approaches suggested below--then lighthouses may work. They should stress within board networking as well as external exchanges. Proposals that have provision for "travelling consultants" who can go from the demonstration site to a newly-adopting site to provide start-up help should be given priority.

21. Pilot grants should be followed by a system of follow-on matching grants for local incremental expansion. To put it another way: multi-year funding should be the normal expectation, dependent on (a) documentation output; (b) modest evidence of success; (c) local expansion plans; (d) networking intentions. In short, the incentive provided by the grants should support the basic thrust of local, widely communicated experimentation.

Reviewing this stream, what will be happening at the ministry level? Once again, we see the importance of a serious financial commitment through matching grants for implementation, follow through, and carefully-designed demonstration, although the costs we suspect, are modest compared to hardware and software contracts. The other key function is ensuring that both ministry and schools can learn from a supported grass-roots process of development, through careful development of documentation and feedback systems that give priority to direct, face-to-face communication.

But back of these initiatives is a crucial issue. This strategic stream lies at the centre of the strategy. More than any of the other streams, its success will rely on a vivid and symbolically powerful communication of the ministry's basic policy. Something like this will have to be said.

"We are in this together as professionals to develop and implement the best possible practices. The energy and vision of teachers and local administrators are the main driving force. It is a shared quest. We are committed to providing a significant share of development,

start-up, support, and dissemination costs. We do not know where we will have arrived in ten years--1996--but we have a central commitment to the quality of our search. This is new, this is important, and we are serious.

Without such communication, the program can regress to partial and feeble efforts, cynicism, and on-paper implementation with little reality. With such communication, buttressed by congruent structural provisions, substantial progress is likely.

What will be happening at the board/school level in this stream? Essentially, boards and schools that want to make a serious start on implementation will be rewarded, not only with financial incentives, but with success in carrying out an initiative that already has priority for them, and has good public support. The documentation and sharing requirements will help them feel part of the larger movement to "do NET right."

D. Diffusing and supporting effective practice.

As implementation proceeds, a systematic strategic stream is needed to locate and select especially promising practices, to disseminate them widely, and to support new users in implementing them. The emphasis here is on "software-in-use." The most practical possibility involves creating a structure drawing on the working principles of the National Diffusion Network in the United States. (4) An Ontario-relevant version would have the following components:

22. A system for identifying well-implemented, effective local practices. Typically, such practices involve a blend of particular software items, a

4 See, for example, the paper by Loucks-Horsley & Roody (1986), which outlines the methods used to diffuse and support classroom applications of a word-processing program, QUILL. The support strategy resulted in QUILL's out-performing the best-selling student word-processing program, Bank Street Writer, in terms of student performance.

classroom management approach, clear linkage to certain curriculum guidelines, and specific instructional procedures. Such practices appear when local schools and boards are invited to apply for "developer/demonstrator" (D/D) grants. A representative Review Panel (containing software experts, local teachers and administrators, consultants, regional assistance centre staff) screens proposals, "verifies" the quality of the practice (in terms of adequacy of documentation and evidence of impact on students) and makes funding decisions. Grants to a D/D should specify that the D/D will maintain a demonstration site where the practice can be viewed.

Some early D/D grants could be made to support practice development. Given the presence of 14,170 GEMS in schools, and reports of GEMS use by about 10% of the secondary and 6% of the elementary teacher population (estimated from the TVOntario survey data, Kwong 1986), there is probably already a modest pool of potentially good practices which only need to have awareness and other supportive materials developed.

There is evidence that locally-developed practices are much more likely to score high on such aspects as legitimacy (teachers like me did this), "fit" with the day-to-day life of schools, easy accessibility, adaptability, and even "inspirational emphasis". All of these make diffusion quicker and easier.

Grant eligibility could easily be extended to universities, OISE and private-sector groups, but the US experience is that local schools predominate. Our recommendation is that joint proposals between universities/TVOntario/OISE/private sector groups and school boards be encouraged.

23. TVOntario, as part of its software dissemination contract, should be asked to develop a directory of approved practices, both in hard copy and on line.
24. Use of TVOntario as an "awareness" channel, coupled with regional awareness conferences, sponsored by regional assistance centres. At such conferences, local developer/demonstrators describe their practices, and distribute awareness materials about their products. Such materials explain the practice generally, provide evaluation data, and

describe implementation requirements and the nature of an "adoption agreement" with the D/D. A public information and dissemination campaign should be launched citing and describing effective, proven practice.

25. The development of contracts between D/D's and local boards, through which the D/D's deliver initial training and follow-up assistance (hands-on-work, planning, coaching) to schools using their practices. Effective contracts will also involve good support materials (teachers' guide) and the development of local facilitators (existing consultants, or local teachers) who can use the materials in training/supporting teachers. The time and expenses of the D/D's would be funded provincially, while local costs (release time etc.) will be provided by local boards.
26. An annual meeting of D/D's and regional centre staff, which serves to strengthen the evolving diffusion network and chart new directions for it.

It is likely that a formal diffusion network of this general sort could be up and operating within three years from the start of major implementation efforts. Getting a good review panel/verification setup in place early helps, as does providing technical assistance to potential D/D's. Normally, it takes two to three years before effective, well-documented practices have stabilized enough to be "diffusable". After the practices are verified, the D/D grants are approved and usually last for three to four years.

27. During the first few years, schools can also benefit from support in software evaluation. The ministry should ask OESS to develop a practical guide for evaluating available OESS software for specific local purposes, perhaps adapting the well-designed software evaluation guide developed by the Council of Ministers of Education (CMEC). The question of whether OESS software should be in an on-line searchable form, like the CMEC database, deserves attention.
28. Software improvement will certainly continue to be a need, as more schools get seriously involved. OESS should be asked to develop methods for getting good feedback from schools, connected with normal documentation requirements. Liaison arrangements should be made to ensure that this feedback from the field is then communicated to the

Software Development Assistance Centre(s) and the ministry's software development program staff.

29. There is also the fact that users will always encounter bugs and short-run problems of use. Maintaining the help line to OESS or the original developer would be very desirable. On-line contact should also be possible. Continuing present support of the OISE Software Development Assistance Centre and (and possible addition of another) also seems desirable.
30. As the next waves of software development proceed, it may also be desirable to support short-run research on effective/ineffective software implementation characteristics as they show up in early implementation (as in the presently-available Gillis (1985, 1986) and Pike (1985) studies).

Summarizing, the ministry's primary function in this stream is to support the development of a practical provincial system for identifying, diffusing and supporting implementation of effective classroom practices (quality software-in-use). We believe that the structures and procedures used in the National Diffusion Network could be readily adapted to the Ontario situation. The United States experience was that NDN took a number of years to evolve to a stable form, and changed and developed considerably as it did so. The implication is that an "Ontario Diffusion Network" (ODN) should grow up gradually, not be wholly pre-planned.

The "evolvment" of the ODN should be presided over by a coordinator and a supporting ministry group, perhaps drawn from the present Software Development section (the Review Panel as previously stated would include appropriate field, university and private sector "experts"). Essentially, components 22 through 26 are oriented toward getting an Ontario-relevant version of NDN planned and into place. (A basic policy question, by the way, is whether the system should be NET-specific, or also include other curricular practices.)

The additional software evaluation and improvement initiatives identified in components 27 through 30 are important as a basic support; work on them should begin immediately.

What will boards and schools be doing? The "early adopters" and "early implementors" will be concentrating on establishing good practices. The potential availability of D/D grants will mean that "enthusiasts" for particular practices will apply. The United States experience was that many more applications appear than could be funded. Furthermore, the development of NDN relied strongly on the energy and esprit among D/D's--much more than on formal government initiatives. In Ontario, it is likely to be a combination of the two.

Once something like an Ontario Diffusion Network is operating, we can anticipate active local engagement with it. Schools and boards would send teachers and administrators to regional awareness conferences, select key practices they regarded as promising, and implement them with D/D training and support.

E. Networking.

Less-formalized networks should also be created. This strategic stream is important because research shows clearly that user interaction and mutual support is key for effective implementation and wider diffusion. Such interaction, starting with the most basic of relationships--the trusted partner--(5) helps address concerns and worries, and supports competence development along with development/adaptation of practices. (We do not speak only of teachers here, but also of administrators and local consultants). Furthermore, networking permits the capturing and recirculating of expertise in direct, practical ways.

5 Note that several studies have stressed the importance of partners for student learning of new technology, as well as for teachers and administrators. Peer-mediated learning is clearly a natural way to proceed.

Several components described in preceding streams have this character already (for example, the regional and provincial support structures for consultants; regional retrieval conferences for grantee boards and schools).

How can networking best be supported? Because this is NET, the natural tendency is to propose that on-line electronic conferencing be widely supported. Though there is no reason not to do this (it costs little, and some users will take to it naturally), standard computer conferencing by itself will not likely have a major affect on classroom practice. The system should contain both computer conferencing and face-to-face components as in TVOntario's current EDAN experimental project, which may provide a prototype for such a system.

31. As already noted, local grants (pilots, implementation, demonstrations) should preferably contain a networking component.
32. In addition, the ministry should create a system of networking mini-grants to local boards, who could apply for modest support for:
 - meetings of teachers, resource staff and principals within or across boards
 - visits
 - part-time network coordinators
 - development of simple data bases to support diffusion and recirculation of effective practices.

Networks could be defined as board-specific or regional, as subject-specific (teaching writing skills, for example, or as level-specific (primary, junior, secondary).

33. The ministry should support the grassroots development of GEMS users associations, by funding an initial GEMS users' conference, pointing toward the creation of a provincial association with regional chapters. This might be done through direct involvement of the Educational Computing Organization of Ontario, with a modest subsidy inviting them to extend and develop their present network.

34. It also seems wise to support the continuing development of the Educational Computing Network of Ontario (ECNO). That will aid in the further development of electronic communication within the province, as well as linking the computing interests of administrators to GEMS/OESS implementation.

The ministry recognizes the potential of expanded electronic communications through ECNO for such functions as administration, software distribution, distance education, access to public and private sector educational data bases and materials, inter-organizational and interpersonal communications and resource sharing. How such a system might actually and effectively contribute to classroom-level NET implementation is really an open question and generalized use of an electronic support-system is unlikely to happen without a stimulus. The ministry could earmark a portion of the recommended in-service and pilot project grants to proposals that incorporate use of electronic communications strategies, once the technology becomes available. It might also contract research on local experimentation with electronic networking for implementation (e.g., user-user/contact, use of resource data bases). Information about local uses of electronic networking to support classroom-level implementation could be disseminated in print and in the workshops already proposed (implementation management, training design etc.).

Finally, electronic networking for implementation could be stimulated by funding the creation of a base of locally developed resource materials for using OESS programs, which would be easily and cheaply accessible through the network under OESS.

What will the ministry be doing in this stream? The basic thrust proposed is that of stimulation and modest financial support. Networking cannot be bureaucratized; it tends to run on local energy and self-interest. But it can be catalyzed through specific interventions like those proposed (mini-grants, conferences, extension of prior networks, see also Devaney 1982).

At the school and board level, networking is the natural method of choice for practitioners engaged in new and demanding practice. People struggling with similar problems--teachers, principals, consultants, board coordinators--like to get together. The main need is to make such association simple and natural,

rather than an "add-on". Time for networking in local proposals, modest support for network-builders, newsletters, one-day conferences, all help.

F. Organizational capacity-building.

As we have noted at several points, the streams we have already discussed are not enough in themselves. For example, heightened teacher competence at using microcomputers will be to no avail if the local school schedule remains so rigid that there is no time to carry out our needed planning and start-up activities. Or, the best system of matching grants will founder if boards cannot manage the collaborative process of teachers and administrators producing good proposals. Or, if local Curriculum, Review, Development and Implementation procedures locally are only a "paper implementation", we can hardly expect that NET will do better at the task of linkage with the curriculum. Finally, if the ministry does not have a well-developed managerial capacity for this large and complex effort, the enterprise will wander and falter.

Thus a crucial strategic stream involves capacity building at both the local and provincial levels--boards and schools in "getting better at managing multiple innovations", along with strengthening the province-wide infrastructure for NET implementation. Several components will be useful here:

35. The ministry should fund, in the second year, a province-wide retrieval conference for principals and local consultants. The aim of the conference would be to examine early implementation experience, with specific focus on organizational patterns that blocked and supported NET implementation efforts. A book of preliminary "guidelines for success" on such matters as scheduling, creation of teacher teams, use of steering and planning groups, approaches to release time, use of specially-designated roles such as coordinators, and other organizational issues would result. A kind of manual (amendable to updating) of the do's and don'ts of implementing NET would be the result.
36. The ministry should commission the development of a workshop on project management skills, which could be offered to key people in boards and schools receiving matching grants. Such workshops could be organized regionally through the Ontario Council for Leadership in Educational Administration.

37. A certain proportion of all matching grants (pilots, demonstrations in-service, follow-on) should be reserved for proposals that have an unusually strong or imaginative organizational capacity-building component. All proposals should have such a component, but having some grants that are primarily organizationally oriented would be useful. Such proposals would address key organizational issues such as the redesign of school structures (team, project groups); redesign of the school day, week or year; redesign of class groupings; or improved linkage between the board and school level.

Another type of high priority proposal would use substantial external technical assistance with a direct emphasis on capacity-building, as in the NAPST project described by Loucks-Horsley & Roody (1986). Joint proposals between universities and school boards which help to build cooperation should be especially promoted.

38. The question of improved infrastructure capacity is discussed further below. Essentially, the ministry needs to take leadership in a careful assessment of the roles and abilities of key agencies--including itself--in the support of NET implementation. A complex strategy of the sort proposed here will not be self-implementing, and agencies will undoubtedly fall short in their present abilities to carry out the parts proposed for them.

We recommend that a variety of capacity building strategies be employed. In some cases, direct grants to boards for pilot projects would occur. In other situations, intermediate agencies like TVOntario or universities (or joint ventures) would play a major role in implementation through project grants.

In summary, the ministry is seen as building local organizational capacity for NET implementation through selective matching grants, through some direct training, and through retrieval and recirculation of grass-roots experience. It must also engage in some careful diagnosis of its own present capacity (both centrally and in regional offices), and that of its organizational partners outside the schools (universities, associations, TVOntario, OESS, etc.)

Schools and boards will be dealing with their own organizational capacity in any case. The important thing is that they recognize the problem of local capacity as a subject for planning and development, not just as an immutable boundary that limits NET implementation. The proposed conference, workshops, and capacity-building grants should do a lot to expand that awareness.

5. TIME LINE AND STRATEGIC MANAGEMENT

How will these six strategic streams play out over time? As a backdrop, we need to consider the tempo of implementation. The issue is fraught with uncertainties and dilemmas. Longitudinal statistics on rate of diffusion of GEMS use to schools and classrooms are not yet available. As part of the ministry's \$10,000,000 start up purchase plan in 1984, all boards in the province got at least one ICON configuration (one fileserver plus three workstations). Statistics on types of microcomputer hardware in place in schools were collected in the Fall of 1986 for the first time as part of the annual September school reports. Ministry figures indicate that after three funding cycles, 1,675 fileservers and 12,494 workstations for grant eligible microcomputer systems had been acquired by school boards. From these data, however, it is impossible to estimate how many schools, teachers and students have access to the machines, since the rate of fileservers to workstations can range from 1 to 1 to 1 to 32, and how they are being distributed across and within schools in each board is up to local authorities (stationary labs, rotating labs, equally distributed, clustered in selected schools, single or multiple stations per class etc.). There are about 4,500 elementary and secondary schools in the province. Of these, 94% (4,245) reported that they had access to one or more microcomputer systems. At least 59% (2,646) of the total school population did not yet report access to GEMS. Schools with access to GEMS only numbered 146 (3%). The actual number of schools using GEMS is larger but indeterminant. A large number of schools (1,453, 32%) claim to have access to two or more microcomputer systems. This would include, but not necessarily be limited to schools with GEMS in addition to some other type of hardware. Even with these additional data, it is not possible to accurately estimate how many schools are using GEMS, and by extension, how many teachers and students have access to them. And even if we could pinpoint the location of the equipment in relation

to teachers, mere access to the hardware and software is not a reliable indicator of its use, i.e. implementation.

The emphasis within the ministry has been to achieve a critical mass of equipment (1 computer per 10 students) and materials in the schools as quickly as possible, within the constraints of available funds. There is a strong argument for this view, in that widespread implementation is unlikely if teachers do not have access to the technology in sufficient quantity to make it worth their while to get involved. While the ministry has not committed itself to a specific timeline at present, it has considered the alternatives. In order to achieve the hardware installed base goal within ten years, for example, the average rate of acquisition of GEMS in boards would have to jump from 4,000 to about 17,000 a year (Executive Committee Paper 1986). The implication is that a lot more money has to be freed up and committed to subsidizing equipment purchases. Of course, there is no guarantee that the ministry will be successful in getting or maintaining the funding it needs to support a dramatically increasing rate of adoption and distribution of technology.

It would be convenient for planning purposes if the spread of this innovation could be predicted directly from figures on the rate of hardware acquisition at the school board/school levels, but such is not the case. As noted, the ministry's estimates of how quickly the GEMS installed base goals could be reached are highly contingent on substantial uncommitted increases in government funding over the next decade. Also, the casual and temporal relations between access to the technology and its use at the school level are not well understood at present. Immediate research on the diffusion of use question would be highly beneficial to ministry planning for implementation support.

The main point, we feel, is that implementation, i.e. teacher use of the technology in the classroom, will be stimulated by but will surely proceed at a slower, less even and less controllable, pace than official adoption and distribution of GEMS and OESS materials. It is more likely to follow the ogive or S-curve pattern typical of the diffusion of innovations. Early adoption is characteristically shown as the "pioneers" begin; then it picks up rapidly as adopters interact and influence each other. The curve slows down later as "laggards" gradually become involved.

The diffusion rate for the kind of NET use desired by the ministry is going to be affected not only by this normal lag between the availability of an innovation and its widespread use, but also by the high uncertainty about how to use it and what good it is going to bring for students and teachers. Given that uncertainty, we would argue strongly that the ultimate fate of this innovation depends less on stepping up the investment in rapid equipment/materials distribution, than it does on focussing more resources and attention towards the quality of early use. We further recommend that allocation of provincial resources to support continued GEMS acquisition should be tied to and follow from an analysis of the costs of supporting the diffusion and stabilization of implementation in the classroom.

There is a need for a more deliberate gradual start at implementation. This will allow for all the "front-end" start-up work that is required, and to insure early small-scale successes before ambitious wide scale efforts start taking hold. A slow start will also enable substantial diversion of financial resources from hardware acquisition into implementation support where they are urgently needed. (We do not recommend diversion from software development, which in our opinion should proceed apace.) In summary, diffusion of this innovation will require significant early support for its use, in addition to the support being provided for its acquisition.

How would the components look, over time? Table 5 displays a very preliminary rough cut, showing key components as they might appear over the first 3-4 years. We have not attempted to be precise or exhaustive, merely illustrative. Detailed operational planning will be required to turn Table 5 into something like a real scheme.

Strategic Stream	1987	1988	1989	1990
A. Competence development	Develop workshops: orientation, classroom mgt. implementation. Invite in-service proposals. Revise Bits & Bytes, revise AQ course.	Give workshops widely. Carry out proposals.	Continue with new adopters.	Continue.
B. Consultant development	Locate local consultants. Develop and begin skills training. Link CROI and NET plans.	Give training. Develop regional support structure.	Continue.	
C. Stimulation/facilitation of naturalistic practice	Set up matching grants scheme; Invite proposals for pilots. Inservice programs. Invite conversion projects (f-blt/GEMS). Let contract for documentation design. Develop feedback/learning systems.	Do pilot implementation projects. Documentation and feedback. Do conversion projects.	Do follow-on projects. Invite demonstration proposals.	Do follow-on projects. Demonstration sites begin.
D. Diffusing/supporting effective practice	Set up review panel and process for identifying existing good practices. Early grants to potential D/Ds for development work. Software evaluation guide developed. Help lines working.	Potential D/Ds refine practices Research on effective software implementation characteristics		D/D's funded for work with schools. TV Ontario does awareness broadcasts; regional awareness conferences. D/D's and schools start contracts.
E. Networking	Mini-grants for network building. Conference of GEMS users. Support ECNO.	Continue Repeat GEMS users conference, start GEMS association.		
F. Building organizational capacity	Develop project management skills workshop. Invite capacity building proposals. Diagnose infrastructure, plan to strengthen.	Give workshop.		Continue.

Table 5 Strategic Streams and Components: Preliminary Sketch for 1987-90

The sketch in Table 5, even in simplified form, indicates graphically just how much management capacity will be required to carry out the NET implementation initiative in a reasonably coherent way. None of the six streams is independent. Questions of timing and the need for orchestration will recur constantly. A strong and clear "vision" for the enterprise is needed, but that will not suffice.

Characteristically, an implementation effort of this sort requires careful attention to planning, initiating, monitoring and managing what is always a complex and uncharted process. This is not only a technical task. Rather, attention must be paid to the political surrounds as they influence implementation; to general "macro-project" management; and to a host of day-to-day operational tasks.

It seems likely that management of the effort should be lodged in the office of the Director of Computer Technology, who in the recent reorganization reports directly to the Assistant Deputy Minister, Learning Programs. (6) He or she will almost certainly need to convene a steering group composed of representatives from major stakeholders, to consider key interim strategic decisions as the program unfolds and evolves.

We do not here offer specific dollar costs for the overall strategy, nor of components within the streams. The Table 5 sketch, and our prior discussion of components, suggests that reasonable agreement on the basic vision should come first.

In principle, we strongly urge that the level of funding for implementation support in proportion to hardware acquisition allocated during the first three years of GEMS distribution needs to be substantially increased. The gist of our argument is that this will (a) achieve higher quality early implementation, and (b) form a stronger basis for justifying additional funds for hardware acquisition. Of course, support for implementation cannot be looked at in a vacuum; funds are also being proposed for electronic network development, and distance education, and the question of the tempo of hardware acquisition must be looked at in a long time line.

6 The Office of Assistant Deputy Minister for Education Technology Development has been phased out as of January 1987, following the original plan that once substantial development had occurred, technology would be integrated into basic operations.

6. CRITICAL REVIEW OF THE RECOMMENDED STRATEGY

Table 6: Assessment of the Strategic Streams Using Criteria

	Comp. devel.	Consult ants	Natur. devel.	Diffus. practice	Network ing	Organ. capac.
1. Local responsiveness	o	*	*	o	*	*
2. Indeterminate initial target	?	?	*	o	?	?
3. Increasing target clarity	?	?	*	*	o	o
4. Learning maximization	o	o	*	*	*	*
5. Credibility high	o	*	*	*	*	o
6. Demandingness reduction	?	?	o	o	?	*
7. Intense, sustained, responsive assistance	o	*	o	o	o	o
8. Expanded assistance capability	o	*	?	*	*	o
9. Support for user interaction	o	*	o	o	*	o
10. Clarity re principal role	?	?	o	?	?	*
11. Attention to time re-allocation	-	-	o	?	?	*
12. Early success likely	*	*	o	*	o	o
13. Use of existing human resources	o	*	*	*	*	o
14. Accommodation of old and new	-	?	*	?	*	?
15. Acceptance of software imperfection	-	?	?	*	?	?
16. Accommodate changing range of user types	*	*	*	*	*	o
17. Iterative, development	*	o	*	*	*	o
18. Coordinate multiple Agencies	*	o	o	?	o	?
19. Provision for parent involvement and support	o	-	o	?	?	?
20. Early success likely	*	*	o	o	*	o
Total	5	8	9	10	0	5

Legend: * Meets criterion adequately
 o Meets criterion partially
 - Does not meet criterion
 ? Uncertain, unknown

In Chapter 4, we outlined a series of 20 criteria for a good strategy. How well does the proposed strategy measure up? Table 6 displays the criteria, and

provides a brief judgment of the adequacy of each thrust, seen as a composite of its components. We discuss Table 6 briefly, and suggest what may be needed to make the strategy even more likely to succeed.

Looking down the columns of Table 6, we can see that the "diffusing effective practice" stream rates well: 10 asterisks and no missing of any criterion. The "naturalistic development" and "networking" streams are nearly as strong, though a few more question marks show up under "networking". The "consultant development" stream is less strong (8 asterisks, but several question marks and one missing). Those needing most strengthening are the "organizational capacity" stream, with many question marks, and the "competence development" stream, which has only five asterisks and three missing items. It could be strengthened by more attention to the "old/new" problem, some addition of work on software evaluation, and acknowledgement of the time reallocation problem as an important part of the implementation management workshop series. Other specific suggestions could be made; the point is that the matrix points to weaknesses in the strategies and suggests ways to improve them.

We should also look across the rows. A row without at least one asterisk points to a weakness in the general strategy, across all streams. There is only one such: parent involvement, which is now handled only partially in the competence development stream (workshop attendance) and the naturalistic development stream (proposal planning, and some involvement in project steering). Strengthening this component on a focussed basis can easily be imagined such as establishing a requirement of parent involvement in naturalistic development and/or in diffusing effective practices.

Criteria that seem especially well met are those of local responsiveness, learning maximization, use of human resources, accommodation of range of user types, and interactive/development style. All these are relatively core criteria, as noted in previous ministry documents. We may conclude from this first critical pass that the overall strategy looks reasonably good in terms of the criteria.

We should also note a good deal of uncertainty about whether the strategy will fit within existing funding constraints, which is a function both of the absence of

specific cost estimates, and a larger uncertainty about the total amounts that will become available.

7. Next Steps

We propose these in telegraphic style, as a first approximation.

- a. Thorough review of the report's analysis and recommendations at ministry meeting of key officials.
- b. Revision, clarification, or extension of the report as advised.
- c. Careful review of the report with representative stakeholder groups (TVOntario, Ontario Teachers' Federations, universities, OISE, administrator associations, boards), as well as with an interactive cross-cutting advisory group drawn from the different populations. The aim is to move toward a shared, coherent vision of the implementation process and the strategic streams.
- d. Assuming a decision to begin operational planning, there should be a clear assignment of planning and coordination responsibility to specific roles, persons and/or groups within the ministry. This should be done in conjunction with a careful review of the appropriate roles of intermediate agencies like TVOntario and local universities relative to the role of the ministry.
- e. Creation of a provincial Implementation Steering Group (multi-role, not just ministry people), directly charged with overseeing initial operational planning, then implementation. It should review the design, implementation and progress of all components, and provide direct policy advice and support to the ministry.
- f. An early task is a sober look at costing, including the idea of reallocating a good deal of hardware money to implementation money (to support quality application in the early years).
- g. The tempo projections made for the next three years should be refined (how many schools and boards to be supported, what proportion of

teachers and classrooms to be involved, number of GEMS to be purchased, size of software pool, etc.)

- h. A public information campaign should be mounted soon.

Conclusion

In this report, we have presented an implementation-focused analysis of provincial policy aims--the "broad picture"--along with "up close" information on how microcomputers are being used now in Ontario schools.

We then proposed a knowledge-based plan for provincial-level action to support local implementation of ministry priorities for new educational technology (NET) between now and 1996. The plan is based on the best available research knowledge on how planned change in education can be carried out through macro- and micro- level strategies.

The report accepts the legitimacy of the ministry's goals concerning the characteristics of hardware and software. The field of NET is changing rapidly, and will continue to do so, as we move from a figure of 6-10% of teachers using official ministry hardware and software, to a higher percentage. Along the way, legitimate arguments can be made for alternatives to the ministry's policy directions. Critical questioning and analysis is essential when innovation directions are both complex and unproven.

But regardless of the direction, we believe that the implementation perspective offered in this report is crucial for success. Since it is based both on available data on the current realities of local implementation in Ontario, and on a synthesis of prior research on the implementation process, this perspective and the resulting plan provides practical food-for-thought, not just for advocates of the ministry's vision, but for those who argue for alternative positions on hardware, software, configurations of use, and outcomes as the complex process of NET implementation unfolds.

When all is said and done, what should the reader take away from this report? What are its crucial messages? They can be stated concisely:

1. Current visions of the potential for NET in education vastly underestimate how difficult it will be for teachers to implement the changes NET will require in practices, materials, beliefs, and skills. Recall our earlier comment:

"It is as if teachers needed to learn to read, and to understand what a book is, at the same time as proceeding to select books, make lesson plans, and carry them out--all the while continuing with their other 'normal' teaching activities."

The tasks of learning about the hardware system, about software, about classroom management, and integration with the curriculum will present teachers with a severe problem of overload; we can expect that it will take a long time before many teachers are engaged in 'quality use'. Furthermore, administrators need to learn a great deal about how to fit NET into the current school organization and how to harness the energies of parents, most of whom are already supportive of NET, at least in principle.

2. The learning task is harder because there are many uncertainties about NET. We do not know very clearly what good-quality use will look like, nor what the real impact on students will be. So boards, principals, and teachers do not have clear guidelines. Furthermore, NET hardware and software are changing and developing continuously. We must invent our own future.
3. Much energy has gone into improving the technical quality of hardware and software. This must be balanced by increasing attention to implementation--the quality of use by teachers and students in the classroom. We need to devote much more time and energy to the question of "how to get there". The identification and spread of effective practices is crucial; the emphasis has to remain on the quality not the ease of implementation.
4. The best models of use will grow out of local implementation. The strategic ideas in this report are centrally built around the idea of "backward mapping". Good implementation must rest on what people in schools are really up against. Thus, the ministry needs to engage local

school personnel in an active, collaborative search for the best ways of using NET. Cumulative, shared learning about NET is the key process.

5. Continued implementation will depend in no large measure on early success, both in terms of teachers' ability to master NET in the classroom, and effects on students' motivation and learning. Thus, we need to look carefully at the impact of use on the learning and attitudes of students, teachers, and parents. Furthermore, at this stage, we should emphasize quality use in a smaller number of schools and boards, before trying to move to wider diffusion.
6. Success will depend on the presence of well-designed, intense, relevant, sustained, assistance--training in needed skills, and follow-up consulting and support. It will probably be the major key to doing a good job with NET. It must be carried out by credible people who have used NET in classrooms; they must provide demonstrations, hands-on experience, follow-up practice, and coaching--building a critical mass of competent users at the local school level. Assistance should focus on school-level groups of teachers rather than on unlinked individuals. Ongoing administrative pressure to engage in a practice driven search for effective implementation will also be necessary, but must be accompanied by assistance.
7. The ministry must assume some important responsibilities if its NET policy aims are to be achieved.
 - a) It must supply direct, active leadership. As we noted, the ministry must in effect be saying:

"We are in this together as professionals to develop and implement the best possible practice. The energy and vision of teachers and local administrators are the main driving force. It is a shared quest. We are committed to providing a significant share of development, start-up, support, and dissemination costs. We do not know where we will have arrived in ten years--1996--but we have a central commitment to the quality of our search. This is new, this is important, and we are serious."

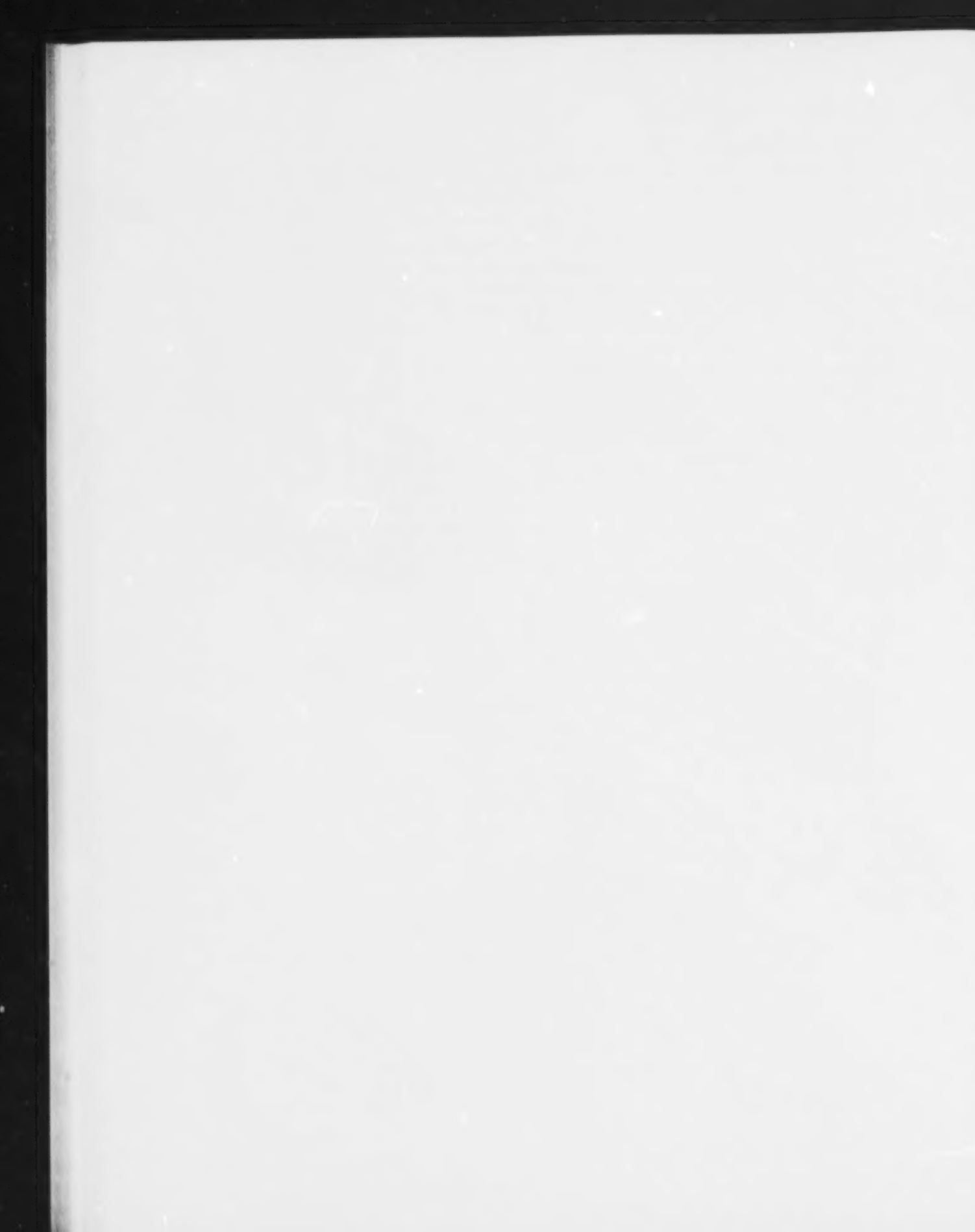
- b) It must engage in serious operational planning, converting the strategies and tactics we have proposed into real, specific activities, clearly costed out.
- c) Given the scope of the task, and the resources available for implementation support (even if expanded, as we recommend), the ministry must rely on capacity-building and multiplier strategies. It is very important to fund strategies which will have widespread payoff (such as workshops in implementation skills, the development of local consultants, and the building of networks). Relatively modest expenditures for well-designed strategies can make a real difference.
- d) There must be steady attention to how the entire enterprise is working, growing, and developing. This means creating a strong steering group that follows progress carefully and considers next steps. In a real sense, the issue for such a group is not only how specific projects are going, but building a good infrastructure for NET in Ontario. This means a good network for sharing well-developed practices across the province, strong regional centres, a cadre of competent assistance-givers, associations of NET users.

We have just posed a strong challenge to the ministry, outlining what it will need to do to "get there". On their part, can the students, teachers, administrators, and parents in Ontario schools meet the challenges that NET implementation poses for them?

At first glance, the task looks enormous, complex, mysterious, daunting--just too much. Yet after all, as it happens, it will happen in one school at a time. People in that school--teachers, their local consultants, the principal, students, parents--will be doing what they can do, in their own terms. If what they do is supported, honored, evaluated, and effectively shared with others--in and out of schools--who are continuously inventing the future of NET in Ontario education, that future will be a bright one.

Given the uncertainties of the intended and unintended consequences of using powerful new technologies, progress must be marked by the regular assessment and dissemination of best practices.

The new educational technology of 1996 is here now in its beginning form. Shaping its form together by carefully and intensively focussing on implementation is the agenda before us.



APPENDIX A

INTERVIEW SAMPLE

Candidates for interviews were recommended by the contractor. Each was identified as having played a key role in one or another aspect of the ministry's NET initiatives to date (e.g. hardware program, software program, strategic planning)

Doug Penny, Assistant Deputy Ministry of Education Technology Development, Ministry of Education

Lorne Smith, Executive Manager, Computers in Education Centre, Ministry of Education

Luella Egerton, Software Development, Computers in Education Centre, Ministry of Education

Bill Mitchell, Research and Strategic Planning, Computers in Education Centre, Ministry of Education

Robert Arn, Meridian Technologies (CEMCorp)

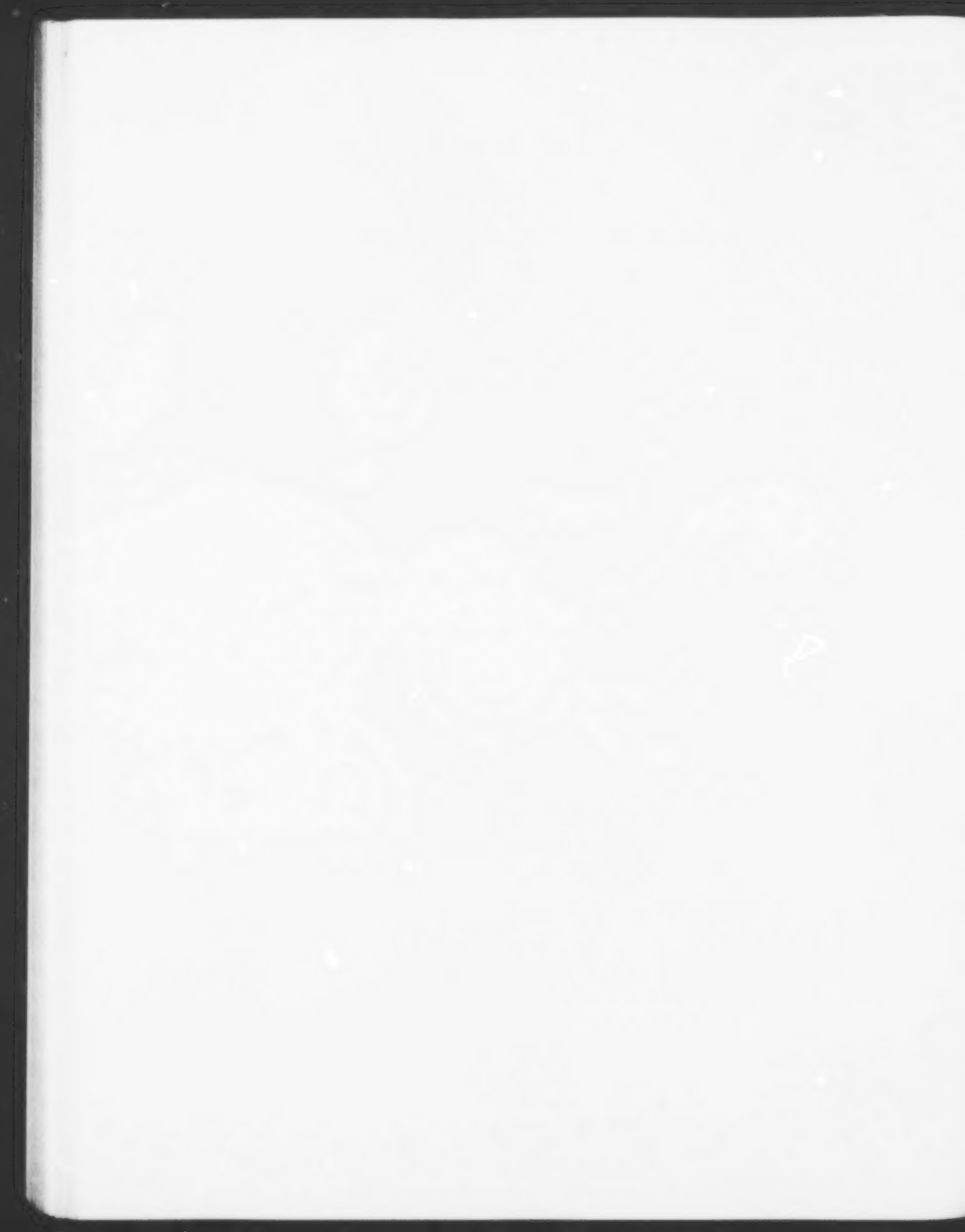
Irv Rubincam, O.I.S.E., Department of Measurement, Evaluation and Computer Applications

Bob McLean, O.I.S.E., Department of Measurement, Evaluation and Computer Applications (Also contributing to this interview were a Graduate student doing doctoral research on microcomputer implementation in schools and a staff person from the O.I.S.E. based Software Development Assistance Centre).

APPENDIX B

NET INTERVIEW GUIDE

1. Informant position and role in NET implementation?
2. Meaning of NET in education?
3. Circumstances motivating ministry involvement in NET implementation?
4. Ministry goals for NET adoption and use?
5. Anticipated outcomes of NET implementation?
 - student
 - teacher
6. Implementation target population? Timeline?
 - teachers
 - students
7. Picture of effective implementation in schools?
 - equipment/materials
 - teacher and student roles/activities
 - principal role/activities
8. Implications for change in existing practices?
 - for teachers and students
 - other (e.g., classroom organization, curriculum)
9. Resource and knowledge needs of teachers?
10. Ministry initiatives and strategies?
 - past
 - current and planned
11. Overall progress of implementation:
12. Obstacles to NET adoption and implementation?
 - past
 - continuing and current
 - obstacles to institutionalization



APPENDIX C

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